The Canadian Entomologist

A Revision of the Genus *Hypenodes* Doubleday with Descriptions of New Species (Lepidoptera, Phalaenidae)

By Douglas C. Ferguson

Nova Scotia Museum of Science, Halifax, N.S.

Until recently only one species of this genus was recognized in North America—*Menopsimus caducus* Dyar. In a paper of 1949, Synonymical Notes Relating to *Menopsimus caducus* Dyar (Proc. Ent. Soc. Wash., Vol. 51, No. 2, p. 74), Mr. J. G. Franclemont established that *caducus* and *fractilinea* Sm. represent two distinct species, congeneric with the European one known as *Tholomyges turfosalis* Wocke, and showed that both *Tholomyges* Lederer and *Menopsimus* Dyar fall to *Hypenodes* Doubleday. Since that time, three more unnamed species have been found, bringing the total for North America to five. All of these, as far as is known, are restricted to the north-eastern region.

I am omitting full treatment of the genotype, *Hypenodes turfosalis* Wocke, because of a scarcity of material for study. There is no way of being absolutely sure that only one species occurs in Europe, or that the specimens seen agree with the type of *turfosalis*. There are before me two European specimens, a male from Finland (Plate II, fig. 1) and a female also from the Zeller collection but without locality label. It might have come from near Stettin, where Zeller lived. These are almost as large as *caducus* and are similarly marked. They lack, however, the contrasty dark brown shades. I have examined only the female genitalia of *turfosalis*, and these are so close to the genitalia of the small bog species I am describing as to indicate a close relationship. The superficial characteristics of size and coloring seem to be about all that distinguishes them.

Hypenodes Doubleday

Hypenodes Doubleday, The Zoologist 8: (Appendix), cv, 1850.

TYPE: *Hypenodes humidalis* Doubleday=*Hypena turfosalis* Wocke=*Hypenodes turfosalis* Wocke (European).

Proboscis much reduced and concealed between the first palpal joints. Palpi long, upcurved. Joint two only slightly compressed laterally, not blade-like as in *Parahypenodes* B. & McD., curved upward around front to near the bases of the antennae. Joint three about four-fifths as long as joint two, slightly curved, acuminate, not compressed and not so reduced as in *Dyspyralis* Warr. Palpi and front densely covered with flattened scales, those on the front broad and shingle-like. Male antennae heavily scaled, not visibly ciliate. Female antennae more slender, finely scaled, minutely ciliate in some species. Legs normal for the group. Venation as shown on Plate I. Moths of small size, 9-15 mm.

The male genitalia are simple but quite characteristic, varying little throughout all six species. The valve consists of two divisions, the main portion being long and slender. At the base of this there is a knob-like process which appears to represent the costal lobe. The uncus is almost linear, or slightly swollen in some species, and bends downward (ventrally) with an even curve. The costal lobes and the uncus bear a few stout bristles. The aedoeagus varies in length but is very simple, with no spine clusters or other inclusions.
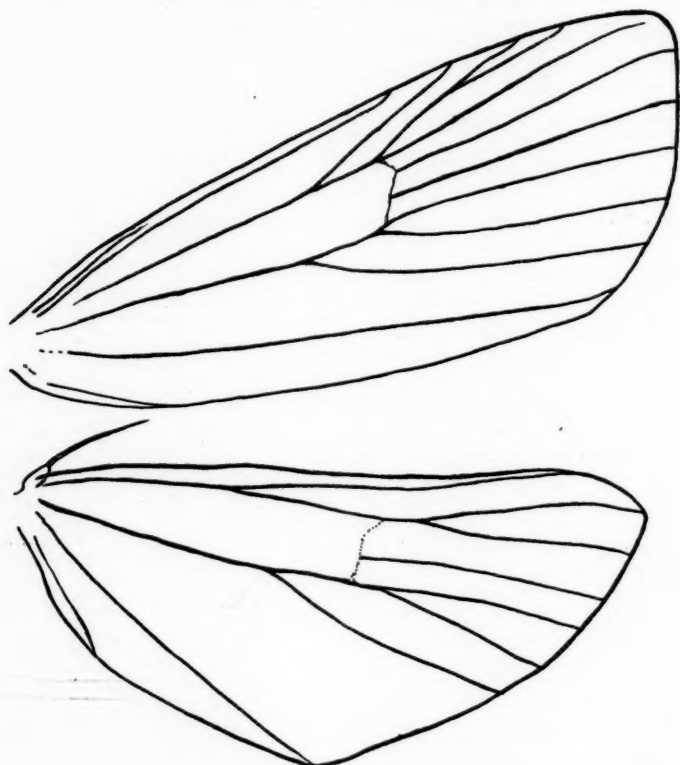
PLATE I

Wing venation of *Hypenodes fractilinea* Sm.

The female genitalia consist of a globular or slightly elongate bursa, which is produced posteriorly (caudally) to form a stout neck region from which emerge both the ductus bursae and the ductus seminalis. This neck region is usually in the form of a stout hook from the outer side of which (closest to the ostium) arises the ductus bursae, and from the very tip of which emerges the ductus seminalis. The form of this hook-shaped part of the neck region varies among the different species. It is doubtful whether the neck region belongs to the bursa or the ductus bursae, but I am tentatively treating it as part of the bursa. The bursa is essentially very membranous, but ventrally, or more commonly towards the left side of the bursa there is a small invaginated area of heavier chitinization, probably representing a rudimentary signum. This spot and an area surrounding it, almost the whole left or ventral half in some species, is finely scobinate. The supposed signum itself does not vary much from one species to another. The distinctly stellate signum portrayed on plate XXIV of the Genitalia of the Pyrales, Deltoids and Plumes, by F. N. Pierce and J. W. Metcalfe, was not to be found in the European species I examined as *turfosalis* Wocke, thus causing me to wonder if their drawing of the female genitalia was based on a misdetermined specimen. What I take to be *turfosalis* is, as expressed also by Franclemont, congeneric in every respect with the American species. The ostium

varies in form as described under each species, but the ovipositor lobes are much alike throughout, resembling those of *turfosalis* shown on Plate III, fig. 7.

Hypenodes is a compact genus of closely allied species, perhaps breeding in some very select habitat although their early stages are still wholly unknown. The third new species described in this paper shows the greatest departure from the normal structural form and maculation, but for all practical purposes remains well within the confines of the genus. Their metropolis would seem to be north-eastern North America where five of the six species occur, and these include the smallest Phalaenids found in this region.

Hypenodes caducus Dyar

Plate II, figs. 2 and 3; Plate III, fig. 1

Menopsimus caducus Dyar, Jour. N.Y. Ent. Soc., 15: 110, 1907.
Menopsimus caducus Dyar, B. & McD. Check List Lepid. Boreal Am., 68, 1917.
Menopsimus caducus Dyar, McDunnough, Check List Lepid. Can. U.S., pt. 1, 129, 1938.
Hypenodes caducus Dyar, Franclemont, Proc. Ent. Soc. Wash., 51, No. 2, p. 74, 1949.

Male and female—Ground color of primaries pale brown; s.t. line, distinct in fresh specimens, edged outwardly with white and inwardly with a wider medium brown shade. The thin, dark brown t.p. line starts in the middle of the inner margin, curves outwardly around the disc and in again, meeting the costa obliquely. Although often incomplete, it is usually a definite line, not a series of dots. The median line has the same point of origin on the inner margin as the t.p. line, but runs almost straight across the wing, through the conspicuous dark brown or black discal spot, thence inward to meet the costa. The median line is bounded outwardly by a white edging, and inwardly by a wide, dark, chocolate brown shade filling half, or in some cases all, of the space between the median line and the rather obscure, crenulate t.a. line. The dark median shade is the most conspicuous feature of the forewing.

Hindwing uniformly pale, gray-brown. Discal spot indistinct or absent.

Scaling of the thorax, front, antennae and palpi generally concolorous with the ground color of the primaries; that of the abdomen concolorous with the secondaries.

Male antennae not visibly ciliate; closely covered with small scales which, towards the tips of the antennae, are raised, giving a roughened appearance. Female antennae more slender, with small ciliations on the outer half where the scales are raised as in the male.
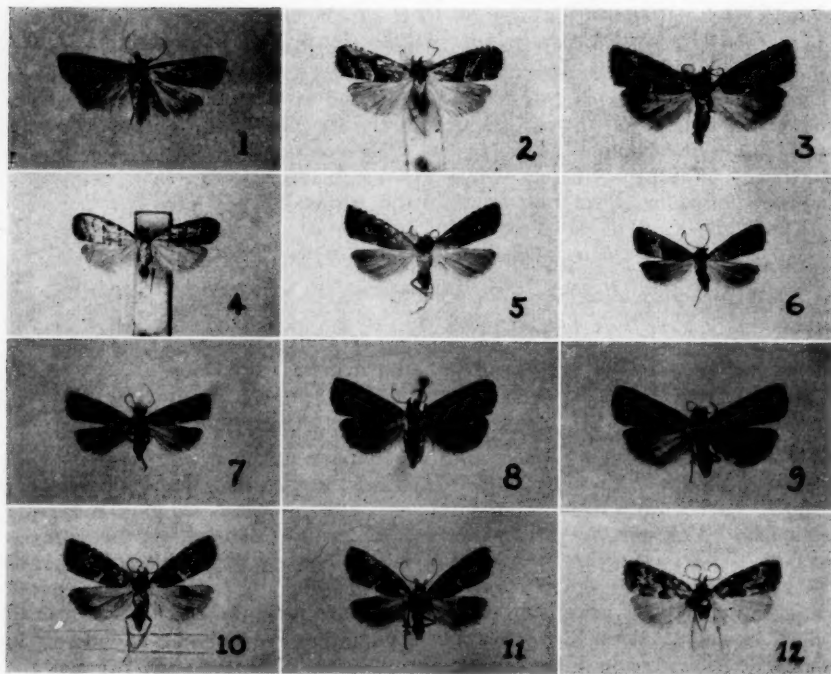
Expanse—13-15 mm.

Caducus is easily recognized by its relatively large size and sharply contrasting light and dark brown shades.

Male genitalia—Thinly chitinized and delicate; tegumen slender. Knob-like process, representing costal lobe of valve, short. Uncus distinctly swollen outwardly where it turns downward.

Female genitalia—Bursa copulatrix elongate, delicately membranous, finely scobinate in limited area around supposed rudimentary signum. Both neck region and ductus bursae rather long. Ostium marked, as in the other species, by a curve or pit in what appears to be the chitinized ventral anterior (cephalic) margin of the ninth segment (see Plate III, fig. 7, female genitalia of *H. turfosalis*), and I shall henceforth refer to this as the ostium pit. In *caducus* the ostium pit is shallow, not a cup-shaped invagination as in *turfosalis* and *fractilinea*.

Type locality—Hampton, N.H.

PLATE II

1. *Hypenodes turfosalis* Wocke ♂. Finland (Zeller collection). This specimen is in the British Museum.

2. *Hypenodes caducus* Dyar ♂. Topotypical. Hampton, N.H., Sept. 11, 1909, S. A. Shaw. In the U.S.N.M.

3. *Hypenodes caducus* Dyar ♂. Freshly emerged specimen from the McLean Bogs Reserve, Tompkins Co., N.Y., June 11, 1947 (J. G. Franclemont coll.).

4. *Hypenodes fractilinea* Sm. ♂. Topotypical. New Brighton, Pa., Aug. 12, 1904, H. D. Merrick (U.S.N.M.). Not a cotype but agrees well with type series.

5. *Hypenodes fractilinea* Sm., rather dark ♀. Mount Uniacke, N.S., July 10, 1951, D. C. Ferguson.

6. *Hypenodes palustris* n. sp. Holotype ♂.

7. *Hypenodes palustris* n. sp. Allotype ♀.

8. *Hypenodes sombrus* n. sp. Holotype ♂.

9. *Hypenodes sombrus* n. sp. Allotype ♀.

10. *Hypenodes franclemonti* n. sp. Holotype ♂.

11. *Hypenodes franclemonti* n. sp. Allotype ♀.

12. *Hypenodes franclemonti* n. sp. ♂. McLean Bogs Reserve, Tompkins Co., N.Y., July 24, 1938 (J. G. Franclemont coll.).

About 1⅔ × natural size.

Photographs by the author.

Type deposited—In the U.S.N.M. The type series bear red labels saying Type No. 10283, U.S.N.M., but it is a mixed series, five of them belonging to *fractilinea*. The original description could apply to either species, but Franclemont designated one of the contrastingly marked specimens as lectotype in his paper of 1949.

Distribution—Passadumkeag, Me. to Connecticut and westward through New York, the Niagara Peninsula (Trenton), Michigan (Livingstone Co.) to the vicinity of Chicago, Ill. and adjacent parts of Indiana. In the original description Dyar mentions it from Washington, D.C., but this could readily have been *fractilinea*.

Habitat—Poorly known. Some have been taken in sphagnous bogs.

Flight period—June 6-Sept. 12.

Hypenodes fractilinea Sm.

Plate I (venation); Plate II, figs. 4 and 5; Plate III, fig. 3

Thalpochares fractilinea J. B. Smith, Ann. N.Y. Acad. Sci., 18: 125, 1908.
Hypenodes fractilinea Sm., Franclemont, Proc. Ent. Soc. Wash., 51, No. 2, p. 74, 1949.

Male and female—Ground color of primaries pale brown; s.t. a faintly whitish line roughly parallel with the outer margin, bordered inwardly by a brown shade. T.p. line represented by a series of faint blackish dots or a thin and vague line running from the middle of the inner margin straight, or with a slight inward curve to just below the disc and back again, meeting the costa obliquely. The median shade runs straight across the wing from the inner margin, through the disc and then curves slightly inward to meet the costa at right angles. The median shade occupies the same position as in *caducus*, but is a much paler, less contrasting shade of brown, sometimes scarcely differing from the ground color. T.a. line a crenulate series of small blackish dots or a thin, broken line. Discal spot when present small, blackish. Hindwings, and the scaling of the head, thorax and abdomen as in *caducus*.

Male antennae as in *caducus*. Female antennae slender, rough-scaled. Short ciliations usually concealed by scales.
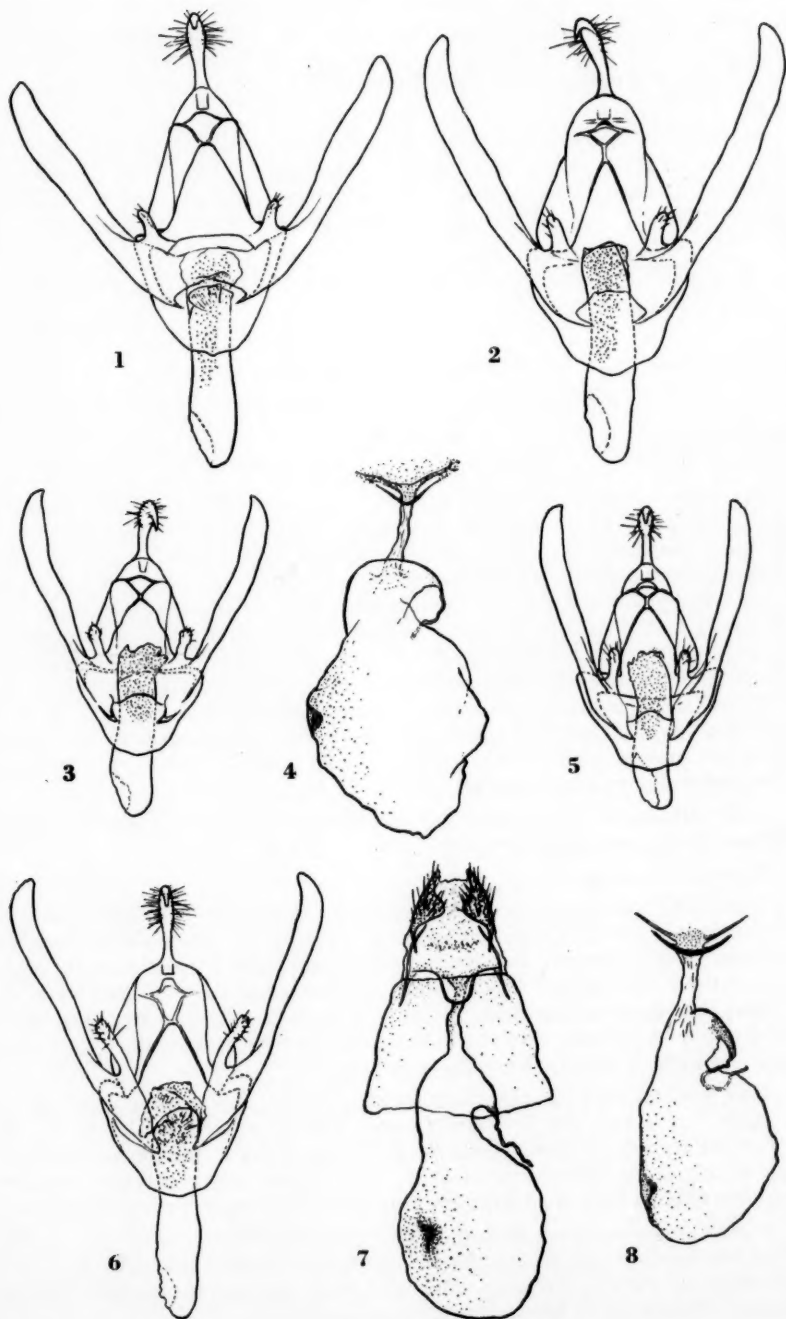
Expanse—11-14 mm.

The above description is based mainly on topotypical material, including two cotypes, in the U.S.N.M., but there is considerable geographical variation. Specimens from Arlington, Va., have a grayer look, lack the dark median shade almost entirely, and have a well defined, rounded discal spot. Those from the Maritime Provinces and northern Maine tend to be a darker brown than topotypical examples, whereas western N.Y. specimens seem abnormally pale. Wisconsin and Indiana specimens are about normal.

Male genitalia—Smaller than *caducus* in accordance with the smaller size of the moth, but appear to be slightly more heavily chitinized. Form of the tegumen differs only slightly. Costal knobs of the valves a little more prominent, rough or rugose in outline towards the ends, where they tend to be swollen. Uncus less swollen than in *caducus* and produced to a longer, more slender point.

Female genitalia—Bursa almost globular but similarly membranous. Entire ventral side minutely scobinate. Neck region well defined, adjoining the bursa more abruptly than in *caducus*. Ductus bursae slender, and shorter than in *caducus*. Ostium pit deeply excavated as in *turfosalis*.

Type locality—New Brighton, Pa.

Type deposited—In the U.S.N.M.

Distribution—Occupies the same area as *caducus* but seems to extend farther north and south. New Brunswick and Nova Scotia south to Arlington, Virginia, and westward through southern Ontario, Michigan, Indiana to Illinois and Wisconsin.

Habitat—Normally in dry mixed or deciduous woodland, although there is a series from the McLean Bog near Ithaca, N.Y. (Franclemont). I take it regularly at light in Canadian Zone climax forest, and find it entirely replaced in acid bogs by the following species.

Flight period—June 2-Sept. 13 through most of its range, but May 23-Oct. 3 at Arlington, Va.

Hypenodes palustris n. sp.
Plate II, figs. 6 and 7; Plate III, fig. 5

Male and Female—Head, thorax, abdomen smoky gray-brown. Antennae, legs and anterior surfaces of the palpi darker.

Primaries light, violaceous gray-brown with darker brown markings. S.t. line almost straight, approximately parallel with outer margin, faintly whitish shaded inwardly with brown. T.p. line very thin, indistinct, originating at the mid-point of the inner margin, running concurrently with the median shade across to the disc where it bends sharply outward and upward to a point about halfway between the reniform and the s.t. line, thence back again parallel to the costa, and finally turning obliquely into the costa at the same point as does the outer edge of the median shade. Median shade occupying the same position as in *fractilinea* but more contrasting, with a thin whitish edging outwardly, giving a sharply defined impression. Discal spot black, rather prominent, sharply defined distally, merging with the dark median shade inwardly. T.a. line an irregular series of blackish dots.

Secondaries smoky gray-brown. Discal spot obscure or absent.

Male antennae as in the previous species. Female antennae with minute ciliations visible near the tip where the scales are raised.

Expanse—Holotype 11 mm.; allotype 12 mm.; paratypes 9-11.5 mm.

Holotype— ♂ , Bog on the Prospect Road, Halifax Co., N.S., July 23, 1952.

PLATE III

1. Male genitalia of *Hypenodes caducus* cotype, Hampton, N.H. (U.S.N.M. Slide No. 725).

2. Male genitalia of *Hypenodes sombrus* n. sp. Mount Uniake, N.S. (N.S.M.S. Slide Hyp. 15 ♂).

3. Male genitalia of *Hypenodes fractilinea*. Annapolis Royal, N.S. (N.S.M.S. Slide Hyp. 10 ♂).

4. Female genitalia of *Hypenodes sombrus* n. sp. showing bursa, ductus bursae and ostium. Annapolis Royal, N.S. (N.S.M.S. Slide No. 230).

5. Male genitalia of *Hypenodes palustris* n. sp. Mount Uniake, N.S. (N.S.M.S. Slide Hyp. 11 ♂).

6. ºMale genitalia of *Hypenodes franclemonti* n. sp. Mount Uniake, N.S. (N.S.M.S. Slide Hyp. 13 ♂).

7. Female genitalia of *Hypenodes turfosalis.* Finland. Specimen and slide in the British Museum.

8. Female genitalia of *Hypenodes franclemonti* n. sp., showing bursa, ductus bursae and ostium. Mt. Uniacke, N.S. (N.S.M.S. Slide No. 231).

Allotype— ♀, Mount Uniacke, Hants Co., N.S., August 18, 1952.

Paratypes—41 ♂ ♂, 4 ♀ ♀, Herring Cove, Peggy's Cove, Halifax Watershed Area and Prospect Road, Halifax Co., Mount Uniacke, Hants Co., and Lake Rossignol, Queens Co., Nova Scotia. June 22-August 24, 1950-52.

The holo- and allotype will be deposited in the C.N.C. Paratypes to the U.S.N.M., A.M.N.H., British Museum, the J. G. Franclemont collection at Cornell University, and various private collections.

Male genitalia—Very similar to *fractilinea* Sm. but a little smaller and of more delicate structure.

Female genitalia—Not unlike those of *fractilinea*, but more elongate, in this respect intermediate between *fractilinea* and *caducus*. Less conspicuously scobinate than *fractilinea*. Neck region of bursa copulatrix very stout, and ductus bursae even shorter than in *fractilinea*. Ostium pit a little deeper than in *fractilinea*.

Palustris is an acid bog or heath species and rarely occurs elsewhere. It is readily confused with *fractilinea* but may be distinguished by the contrasty maculation, the violet tint seen in fresh specimens, its small size and bog habitat. It is the smallest *Hypenodes* and perhaps the smallest Phalaenid in North America. Outside of Nova Scotia I have taken it only on the Passadumkeag Bog, Maine, where it is common, and have specimens from Bangor and S.W. Harbour Bog, Maine. These are somewhat darker than the types. A couple of specimens from the McLean Bog, near Ithaca, N.Y. may belong here, but fresher material is needed.

Hypenodes sombrus n. sp.

Plate II, figs. 8 and 9; Plate III, figs. 2 and 4

Male and female—Head, thorax, abdomen, antennae, palpi and legs all unicolorous smoky gray-brown.

Primaries deep sooty gray-brown, darker than any other species. Very fresh examples, such as the allotype, show a strong dusting of whitish scales, producing a hoary effect. Aggregations of these whitish scales along the outer edge of the t.p. and subterminal lines reveal the positions of these lines, otherwise generally obscured in the dark ground color. S.t. line almost straight. T.p. line is a series of faint blackish dots curving outwardly around the cell as in the species already discussed. T.a. line marked only by óne or two very faint blackish dots. Discal spot partly obscured but wedge-shaped, the apex directed toward the base of the wing. Distal side of the triangular discal spot concave, the concavity filled with an aggregation of white scales. The median shade, contrastingly dark in the other species, is here scarcely distinguishable from the general ground color. Fringes concolorous.

Secondaries smooth, smoky gray-brown as in the other species, but a little darker.

Neither the male nor female antennae differ noticeably from those of *palustris*.

Expanse—Holotype 14 mm.; allotype 15 mm.; paratypes 13-16 mm.

Holotype— ♂, Concord, N.H., July 6, 1953 (D. C. Ferguson).

Allotype— ♀, same data.

Paratypes—16 ♂ ♂, 11 ♀ ♀, Concord, N.H., Lake Rossignol, Queens Co., Annapolis Royal, Annapolis Co., Auburn and Aylesford, Kings Co., Mount Uniacke, Hants Co., Petite Riviere, Lunenburg Co., Waverley, Halifax Co., and Baddeck, Victoria Co., Nova Scotia. June 17-Sept. 2, 1948-53.

The holo- and allotype will be deposited in the C.N.C. Paratypes to the U.S.N.M., A.M.N.H., British Museum, the J. G. Franclemont collection at Cornell University, and various private collections.

Male genitalia—Almost the same as those of *caducus* except for minor differences in the form of the tegumen. Also, the knob-shaped costal lobe of the valve is a little stouter, and the valve itself somewhat longer than in *caducus*.

Female genitalia—Bursa copulatrix relatively large, elongate and irregularly shaped. Neck region very stout, ductus bursae rather short. The depression thought to represent the signum is quite prominent, but only a small area surrounding it shows the finely scobinate texture. Most of the bursa is smooth, very thin and membranous. The ostium pit is obtusely V-shaped and shallow, much as in *caducus*.

Hypenodes sombrus is the largest species of the genus and is readily recognizable by its dark, sometimes almost blackish coloring that all but obscures the usual lines and shades of the primaries. It appears to be most closely related to *caducus*. The habitat of *sombrus* varies surprisingly. I found it coming to light commonly in the middle of a cat-tail marsh at Aylesford, N.S., on the Passadumkeag Bog, Maine, and again in dry white pine woods a mile or so west of Concord, N.H. Individual specimens have also turned up in dry woodland in Nova Scotia and elsewhere.

Sombrus appears to be quite widespread in the north-east, and it seems curious that it should have so long escaped notice. In addition to those localities already mentioned, I have examined specimens from the vicinity of Ottawa (C.N.C.), and two quite normal looking examples taken at Cow Head and Daniel's Harbour, N.W. Newfoundland by Dr. Harry Krogerus of Helsingfors, Finland.

Hypenodes franclemonti n. sp.
Plate II, figs. 10-12; Plate III, figs. 6 and 8

Male and female—Strikingly different from all other species. Antennae, palpi, head and thorax pale brown with an interspersion of whitish scales. Abdomen uniformly pale brown with a satiny lustre. Legs pale brown, tending in very fresh specimens to be ringed at the joints with whitish.

Primaries light brown with a dark brown median area that contrasts sharply. A basal line is indicated by a single blackish streak running inward from the costa. The well defined, dentate t.a. line edged basally with white. The course of the t.p. line is unusual, running upward and slightly inward from near the mid-point of the inner margin, to about the middle of the wing, where it curves sharply outward, forming two lobe-shaped processes beyond the disc, and then running inward again before turning sharply into the costa, which it cuts about midway between base and apex. The entire median area between the t.a. and t.p. lines is filled with dark brown, which becomes palest basally and darkest adjacent to the t.p. line. The discal spot falls within the darkest area and hence is largely obscured. In the excavation between the two projecting lobes of the t.p. line there is often a blackish dot, but this is not the true discal spot. Both the t.p. and s.t. lines are well defined by an edging of white scaling which diffuses outwardly, merging with the darker ground color. Between the t.p. line and the apex, the costa is checkered with dark brown and whitish scaling, and the outer margin is marked by a series of blackish spots just before the fringes, which are uniformly light brown or but faintly checkered. Even slightly worn or faded specimens, such as the allotype, do not show all of these markings well.

The secondaries and their fringes are unicolorous pale brown, lighter than in any of the other species.

Male antennae very rough; ciliations, if present, not protruding beyond the raised scales. Female antennae normally slender, rough-scaled, not visibly ciliate.

Expanse—Holotype 13 mm.; allotype 12 mm.; paratypes 11.5-14 mm.

Holotype— ♂ , Halifax Watershed Area, Halifax Co., N.S., Aug. 10, 1950.

Allotype— ♀ , Herring Cove, Halifax Co., N.S., Aug. 17, 1950.

Paratypes—17 ♂ ♂ , 2 ♀ ♀ , Armdale, Herring Cove, Halifax Watershed Area and bog, Prospect Road, Halifax Co., Mount Uniacke, Hants Co. and W. Northfield, Lunenburg Co., Nova Scotia, July 10-Aug. 17, 1948-52.

The types of *franclemonti* will be distributed in the same manner as those of *sombrus* and *palustris*.

Male genitalia—Normal for the group, but still show the most extreme development of one or two features. The uncus, valves and aedoeagus are all of very slender form. The uncus is only very slightly swollen. The most conspicuous difference is found in the costal lobe of the valve. It is over twice the length found in any other species and would be better described as club-shaped rather than knob-like.

Female genitalia—Bursa somewhat elongate, neck region stout, scobinate area about supposed signum quite extensive. The hook-shaped end of the bursa neck terminates in a long, chitinized process, from the tip of which arises the ductus seminalis. This chitinized process is lacking in the other species. Ductus bursae short; ostium pit shallow as in *caducus* and *sombrus*, not deeply U-shaped as in *fractilinea*, *palustris* and *turfosalis*.

The habitat of *Hypenodes franclemonti* is rather indefinite, but it appears to be associated with acid soil conditions. Of the fifty specimens examined, nearly all were taken in sphagnous or heathy bogs. I have had a very few come to light in dry woodland, but usually in granitic areas where there was an abundance of such vegetation as *Vaccinium*, *Gaylussacia*, *Kalmia* and oak, all indicative of acid soil.

Franclemonti seems to occupy about the same range as the other two new species. In addition to the localities in south-eastern Nova Scotia, I have taken it on the Passadumkeag Bog, Maine, and have examined single specimens from the McLean Bogs Reserve, near Ithaca, N.Y. (Franclemont coll.) and from the Ottawa region (C.N.C.). It is rare in collections.

This species is named for Mr. John G. Franclemont, of the Dept. of Entomology at Cornell University, whose willing assistance has been of great value to the preparation of this paper. While on the subject of acknowledgments, I must also mention my indebtedness to the authorities of the United States National Museum for the loan of their material, and similarly to Mr. Alex K. Wyatt of Chicago upon whose material are based the distribution records for Michigan, Illinois and Indiana.

I would arrange the North American species of *Hypenodes* as follows:

HYPENODES Doubleday
   Schrankia H.-S.
   Tholomyges Led.
   Menopsimus Dyar
      caducus Dyar
      sombrus Ferguson
      fractilinea Sm.
      palustris Ferguson
      franclemonti Ferguson

Carabid Beetles from Nova Scotia

By CARL H. LINDROTH

Zoological Institute of the University
Lund, Sweden

The literature dealing with the coleopterous fauna of Nova Scotia is extremely scanty, the old lists of Jones (1869) and Evans (1899) still being the most comprehensive treatments of the subject. Leng (1920), it is true, interested principally in limital records, indicated in his catalogue the presence in Nova Scotia of all species known by him to occur there. But a list compiled from his catalogue is far from complete. Of recent papers, two by Brown (1940, 1950) on introduced European species are the most interesting.

My own interest in the region arose from the desire to get a picture, as complete as possible, of the Nova Scotian carabid fauna as a background for more intensive studies on the same family in Newfoundland, where work was carried on for two summers with grants from the Arctic Institute, the Rockefeller Foundation, and the Swedish Government.

The sources of the material included in the following list of species are: (1) Published records given in the references that follow the list. (2) Specimens preserved in the following public and private collections: Department of Agriculture, Ottawa (DAO); Museum of Comparative Zoology, Cambridge, Mass. (MCZ); American Museum of Natural History, New York (AMN); National Museum, Washington, D.C. (NMW); Nova Scotia Museum of Science, Halifax (NSM); the rich collection of Mr. C. A. Frost, Framingham, Mass. Study of these collections was made possible by a generous grant from the Rockefeller Foundation, which enabled me to spend four months on such work in the United States and Canada during the spring of 1951. (3) My own collecting from May 18 to 28, 1951; a complete collection of the species included in this material will be deposited in the Nova Scotia Museum of Science, and a duplicate series with the Department of Agriculture, Ottawa. I am especially indebted to Mr. Douglas C. Ferguson of the Nova Scotian museum, who facilitated in many ways my visit to Nova Scotia and who, at my request, collected a number of carabids during 1951 and 1952.

The following list includes 186 species, besides three dubiously recorded. In order to save space, the total distribution and the ecology of the species are, as a rule, not given. I hope to deal with these matters at some length in the forthcoming Newfoundland paper. I have attempted to give as complete a list as possible but have not detailed the distribution of the species within the limits of Nova Scotia. It was considered of special interest, however, to report occurrences on Cape Breton Island (C.B.I.), the northernmost part of the province.

Abbreviations used for the names of collectors are:

Bls.	P. G. Bolster	Fgn.	D. C. Ferguson
Bwn.	W. J. Brown	Fst.	C. A. Frost
Lth.	C. H. Lindroth	Ncy.	A. S. Nicolay

!–the exclamation point indicates that the material was seen by myself.

List of Species

Cicindela repanda Dej.—Widely distributed; north to Ingonish (Fgn., NSM!) on Cape Breton Island. The Nova Scotian specimens have been referred to a special race, *novascotiae* Vaurie (1951, p. 1).

C. duodecimguttata Dej.—Widely distributed over the province, north to Ingonish, C.B.I. (Fgn., NSM!). The green variety is not rare (MCZ! NSM!).

C. hirticollis Say.—Summerville; White Point Beach, Queens Co.; Cow Bay, Halifax Co.; Ingonish, C.B.I. All of these localities have been reported by Cazier (in litt.).

C. limbalis Klug.—Cape Breton Island (Harris, 1911, p. 6; MCZ!); Baddeck, two examples (Fgn., NSM!).

C. longilabris Say.—Widely distributed; north to North Sydney on Cape Breton Island (several collectors!). All individuals seen are black and unmetallic.

C. tranquebarica Hbst. (*vulgaris* Say).—Several localities! Extends on to Cape Breton Island, (Fletcher, 1905, p. 73; Harris, 1911, p. 18).

C. sexguttata Fab.—Several localities (Bwn., 1930, p. 150; Fst! NSM!). Not known from Cape Breton Island.

Sphaeroderus canadensis canadensis Chd. (*Blanchardi* Leng, *vide* Darlington, 1933, p. 62).—South Milford, Annapolis Co., June 26, 1951, one example (Fgn., NSM!).

S. nitidicollis Brevoorti Lec.—Sackville River, May 20, 1951, one example (Lth.).

(There is an old record (Jones, 1869, p. 143) of *S. Lecontei* Dej. from Nova Scotia. Although this occurrence is most probable, confirmation is awaited).

Carabus maeander Fisch.—Apparently rare; also taken on Cape Breton Island (MCZ!) at North Sydney (Lth.).

C. granulatus L.—Like *C. nemoralis*, this European species was first recorded in America from New Brunswick in 1890 (Brown, 1940, p. 69). Since 1910, known also from Nova Scotia (Brown, l.c.), where it now has a wide distribution (DAO! MCZ! NSM! Lth.); not known from Cape Breton Island.

C. nemoralis Müll.—This European species, first taken in America in New Brunswick in 1890, has been known from Nova Scotia since 1924 (Brown, 1940, p. 69). It is now widely distributed in Nova Scotia (DAO! NSM! Lth.) but seems not to have invaded Cape Breton Island as yet.

C. serratus Say.—Several localities (DAO! NSM!); Port Hawkesbury (MCZ!) and Cheticamp (Lth.), C.B.I.

Calosoma frigidum Kby.—Halifax, Armdale, Sept. 14, 1950 (immature), June 20, 1952 (Fgn., NSM!).

C. calidum (Fab.).—Several localities (DAO! NSM!); common at North Sydney, C.B.I. (Lth.).

Elaphrus Clairvillei Kby.—Westchester Lake, Cumberland Co. (Fst., DAO!); Waverley, (Lth.).

E. olivaceus Lec.—Westchester Lake, Cumberland Co. (Fst., DAO!).

E. riparius (L.).—Coldbrook, Kings Co.; Three Brooks, Pictou Co. (Fgn., NSM!). Also from Nova Scotia in the Museum of Comparative Zoology.

Blethisa Julii Lec.—Originally described from Nova Scotia (three examples in the LeConte Collection). Cheticamp, C.B.I., on the flooded delta of the river, May 25, 1951, one example (Lth.).

B. quadricollis Hald.—Cheticamp, C.B.I., one example with *Julii*; North Sydney, C.B.I., one example (Lth.).

B. multipunctata aurata Fisch. (*hudsonica* Csy.).—Cheticamp, C.B.I., five examples with *Julii* (Lth.).

Loricera pilicornis (Fab.). (*coerulescens auct.*, *neoscotica* (Lec.).–Several localities (DAO! MCZ! NSM!); north to Cape North (Lth.). The types of *neoscotica* Lec. (MCZ!) are true *pilicornis*.

Notiophilus aquaticus (L.).–Parrsboro, Cumberland Co. (DAO!); from Nova Scotia also in the Liebeck Collection (MCZ!).

N. aeneus (Hbst.).–Lapland, Lunenburg Co., Sept. 1, 1952 (Fgn!).

?*Pelophila borealis* Payk. (*Ulkei* Horn, *Shermani* Csy.).–In the Frost Collection, there is one example labelled Boisdale, C.B.I., 18-19. VII. (loc. nr. F3117), Leng. The record seems doubtful, partly because other Leng specimens, in the American Museum of Natural History, bear incorrect labels, partly because it is surprising that Leng did not mention in his catalogue the unexpected capture in Nova Scotia of this pretty northern beetle.

Nebria pallipes Say.–Two examples from Nova Scotia in the LeConte Collection.

Dyschirius nigripes Lec.–Waverley, two examples at the margin of a small, eutrophic pond (Lth.); Coldbrook, Kings Co., one example (Fgn.!).

D. longulus Lec.–Yarmouth, June 28, 1947, one male, the genitalia on a slide (Bwn., DAO!).

D. sellatus Lec.–Crescent Beach, associated with *Bledius* sp., May 19, 1951, five examples (Lth.).

Clivina fossor (L.).–This European introduction was first taken in America at Montreal, Que., in 1915 (Fall, 1922, p. 162; MCZ!) and was found at Weymouth, N.S., in 1922 (Fall collection, MCZ, as *collaris*!). It is widely distributed in Nova Scotia (Brown, 1950, p. 198); Orangedale and North Sydney, C.B.I. (Lth.).

C. americana Dej.–Kedgemakooge, Queens Co. (Ncy., MCZ!); Bridgewater, abundant on river banks (Lth.).

Bembidion (*Chrysobracteon*) *inaequale* Say (*lacustre* Lec.).–Coldbrook, Kings Co. (Fgn!); Sackville (Fgn!); Riversdale (Lth.); Cape North, C.B.I., abundant (Lth.).

B. (*C.*) *carrianum* Csy. (*litorale auct.* American, *nec* 01., *lacustre* Fall, *nec* Lec.).–C.B.I. (MCZ!); Cape North (Lth.).

B. (n. subg.) *chalceum* Dej.–Bass River and Portaupique (Fst., MCZ!); Bridgewater, Sackville, and Riversdale (Lth.); Cheticamp and Cape North, C.B.I. (Lth.).

B. (*Metallina*) *properans* Steph.–Dartmouth, June 3, 1947, one example (Bwn., DAO!); Halifax, 1951 and 1952, five examples (Fgn!, Lth.); Riversdale, one example (Lth.); Crescent Beach, one example (Lth.). This European introduction has not been reported previously from America. All American specimens seen are macropterous; their genitalia agree completely with those of European specimens (Lindroth, 1940, fig. 9).

B. (*Plataphus*) *planatum* Lec.–C.B.I.: Cheticamp, four examples, Cape North, one example.

B. (*P.*) *rusticum* Csy. (*planiusculum auct.*, *nec.* Manh.).–Generally distributed and abundant (Fst!, Lth.); north to Cape North (Lth.).

B. (*P.*) *flebile carolinense* Csy. (*complanulum auct.*, *nec.* Manh.).–Bass River and Portaupique (Fst!, MCZ!); Riversdale (Lth.); Cheticamp and Cape North, C.B.I., abundant (Lth.).

B. (*Plataphodes*) *occulator* Notm.—Sackville, three females (Fgn!, Lth.).

B. (*Trichoplataphus*) *planum* Hald. (*Guexi* Chd.).—Widely distributed (Brown, 1930, p. 151; Fst!; Lth.), but unknown from Cape Breton Island.

B. (*Hirmoplataphus*) *nigrum* Say.—Several localities (MCZ!); north to Cape North (Lth.).

B. (*H.*) *salebratum* Lec. (*concolor auct.*, *nec* Kby.).—Bass River (MCZ!); Bridgewater (Lth.); Cheticamp and Cape North, C.B.I., abundant (Lth.).

B. (*H.*) *longulum* Lec. (*concolor* Kby., *nomen validum*).—Bass River (Fall Collection, MCZ!).

B. (*Peryphus*) *ustulatum* (L.) (*tetracolum* Say).—Halifax (DAO!, Lth.).

B. (*P.*) *rupestre* (L.).—This European introduction, not known previously from America, was found in 1907 in Newfoundland and in 1910 at Port Medway, Queens Co., N.S. (Bls., MCZ!). Other Nova Scotian localities are Riversdale (Lth.); Coldbrook, Kings Co. (Fgn!); Shad Bay, Halifax Co. (Fgn!); Orangedale, C.B.I. (Lth.).

B. (*P.*) *petrosum* Gebl. (*lucidum* Lec., *nec auct.*, *substrictum* Lec.).—Several localities on Cape Breton Island; north to Cape North (DAO!, MCZ!, NSM!, Lth.).

B. (*P.*) *transversale* Dej.—C.B.I.: Glace Bay (MCZ!); Cheticamp and Cape North (Lth.).

B. (*P.*) *sejunctum* Csy.—Cheticamp, C.B.I., two examples on the sandy margin of a lagoon, May 25 (Lth.).

B. (*P.*) *scopulinum* (Kby.).—Several localities (DAO!, MCZ!, Evans, 1899); north to Cape North (Lth.).

B. (*Hydriomicrus*) *semistriatum* Hald.—Several localities (Brown, 1930, p. 151, DAO!, Lth.), but unknown from Cape Breton Island.

B. (*Eupetedromus*) *incrematum* Lec. (*dentellum auct. Amer.*, *nec* Thnb.; *arcuatum* Lec.).—Sackville (Lth.); Baddeck and Cape North, C.B.I. (Lth.). Recorded from Nova Scotia by Hayward (1897, p. 98).

B. (*E.*) n. sp.—Kedgemakooge, Queens Co., one example (Ncy, MCZ!); Cheticamp, C.B.I., one example from the delta of the river (Lth.). Known also from Newfoundland, Quebec, and New Hampshire; the description will appear in a paper on the Carabidae of Newfoundland.

B. (*Notaphus*) *contractum* Say.—Yarmouth and Halifax (DAO!); Crescent Beach Lth.).

B. (*N.*) *constrictum* Lec.—Yarmouth (DAO!); Orangedale, C.B.I., at brackish water (Lth.).

B. (*N.*) *patruele* Dej. (*intermedium* Kby.; *variegatum* Lec., *nec* Say).—Coldbrook, Kings Co., abundant (Fgn!).

B. (*N.*) *posticum* Hald. (*fraternum* Lec.).—Generally distributed (in the LeConte collection, MCZ, as "*variegatum*"!, AMN!, NSM!); north to Cape North (Lth.).

B. (*Furcacampa*) *decipiens* Dej. (*versicolor* Lec., *nec* Csy.).—Generally distributed (DAO!, MCZ!, NSM!); north to Cape North (Lth.).

B. (*F.*) *mimus* Hayw. (*versicolor* Csy., *nec* Lec.; *pellax* Csy.).—Widely distributed (MCZ!, AMN!, NSM!); north to Cheticamp, C.B.I. (Lth.).

B. (*s. str.*) *mutatum* G. and H.—Portaupique, Colchester Co. (Fst., Brown, 1930, p. 151; DAO!); Sackville (Fgn!).

B. (*s. str.*) *quadrimaculatum oppositum* Say.—Widely distributed (DAO!, MCZ!, NSM!); north to North Sydney, C.B.I. (Lth.).

B. (*Semicampa*) *semicinctum* Notm.—Riversdale, three examples (Lth.).

B. (*S.*) *muscicola* Hayw.—Halifax, one example, and Sackville, two examples (Lth.); C.B.I.: Cheticamp, 13 examples, North Sydney, nine examples (Lth.). Only one example from Sackville and one from Cheticamp are macropterous.

B. (*Diplocampa*) *transparens* Gebl. (*sulcatum* Lec.).—Yarmouth (DAO!); Sackville (Lth.); C.B.I.: Baddeck, Cheticamp, North Sydney, and Cape North, abundant (Lth.).

B. (*Trepanedoris*) *frontale* Lec.—Kedgemakooge, Queens Co. (Ncy., AMN!); Coldbrook, Kings Co. (Fgn!); Bridgewater, Sackville, Riversdale (Lth.). Not known from Cape Breton Island.

B. (*T.*) *anguliferum* Lec.—Generally distributed and abundant (MCZ!, AMN!, Blackwelder, 1939, p. 12); north to Cape North.

Tachyura granaria (Dej.).—Sackville (Lth.); Baddeck, C.B.I. (Lth.). This species occurs independently of water.

T. incurva (Say).—Truro, Riversdale, 3 examples (Lth.).

T. xanthopus (Dej.).—Kedgemakooge, Queens Co. (Ncy., MCZ!, AMN!); Bridgewater, exceedingly abundant on the river banks (Lth.); Riversdale (Lth.).

T. tripunctata (Say).—Portaupique, Colchester Co. (Fst., DAO!); Riversdale, abundant (Lth.); Cheticamp and Cape North, C.B.I. (Lth.). Always on river banks.

Tachyta angulata Csy.—Portaupique, Colchester Co. (Fst., DAO!); Halifax (Fgn!, Lth.); Sydney, C.B.I. (DAO!).

Patrobus longicornis (Say).—Several localities including Cape Breton Island (DAO!, MCZ!, AMN!).

Platidius rugicollis (Rand.).—Portaupique, Colchester Co. (Fst., DAO!; Darlington, 1938, p. 152); Riversdale (Lth.); Cape North, C.B.I., abundant on the sandy river bank (Lth.).

Trechus apicalis micans (Lec.) (*rubens* Schffr., *nec* Fab., *nec* Horn).—Portaupique, Colchester Co. (Fst., DAO!); Sackville (Lth.).

T. rubens Fab.—The LeConte Collection (MCZ!) contains five examples from Nova Scotia (Horn, 1875, p. 131; 1882, p. 48).

Pterostichus (*Poecilus*) *lucublandus* (Say).—Generally distributed and common; north to Cheticamp, C.B.I. (Lth.). The "*convexicollis*" of Evans (1899, p. 321), according to one example from Halifax (DAO!), belongs here, as does probably the "*chalcites*" of Jones (1869, p. 144).

P. (*Gastrellarius*) *honestus* Say.—Recorded from Nova Scotia by Leng (1920). I have seen no specimens, but the species is very characteristic and the determination therefore probably right.

P. (*Hypherpes*) *adoxus* (Say).—Kentville, Kings Co. (Gibson, 1917, p. 146). I have seen no specimens, but the species is so characteristic that there seems to be little reason to doubt the identification.

P. (*Omaseus*) *melanarius* (Ill.) (*vulgaris auct.*, *nec* L.).—The first American capture of this European insect was made at Pugwash, Cumberland Co., in 1926; Annapolis Royal, 1947 (Brown, 1950, p. 198; DAO!).

P. (*O.*) *coracinus* (Newn.).—Widely distributed; north to Cape North (Lth.).

P. (*Melanius*) *luctuosus* (Dej.).—Generally distributed; north to North Sydney, C.B.I. (Lth.).

P. (*Lagarus*) *Leconteianus* Ltsh. (*erythropus* Dej., *nec* Marsh.; *nitidus* Kby., *nec* Dej.).—Crescent Beach (Lth.); Cheticamp, C.B.I. (Lth.). Both specimens were found on the seashore.

P. (*Argutor*) *patruelis* (Dej.).—Generally distributed and common; north to Cape North (Lth.).

P. (*Dysidius*) *mutus* (Say).—Several localities (MCZ!, NSM!, Lth.); apparently does not occur on Cape Breton Island.

P. (*Bothriopterus*) *adstrictus* Esch. (*Luczotii* Dej.).—Armdale, Halifax Co. (Fgn!); C.B.I. (MCZ!).

P. (*B.*) *pennsylvanicus* Lec.—Aldershot, Kings Co. (Fgn!); Sackville (Lth.); Three Brooks, Pictou Co. (Fgn!).

Amara (*Cyrtonotus*) *aulica* (Panz.).—This European introduction, known in America only from Nova Scotia and Newfoundland, was collected first at Louisburg, N.S., in 1929 (Fall, 1934, p. 171; MCZ!). It has been found on Cape Breton Island at Port Bevis, 1934, one example (H. H. Vogel, Jr., NMW!); Cape North, two examples (Lth.); and North Sydney, seven examples (Lth.).

A. (*C.*) *pennsylvanica* Hayw.—Halifax, one example (DAO!).

A. (*Bradytus*) *avida* (Say).—Halifax (Lth.); Cow Bay and Dartmouth (Bwn., DAO!); Orangedale and North Sydney, C.B.I. (Lth.). It has been reported from Nova Scotia by Hayward (1908, p. 38, MCZ!); possibly the "*exarata*" of Evans (1899, p. 321) refers to this species.

A. (*B.*) *fulva* (Deg.).—North Sydney, C.B.I., two examples (Lth.). This introduced species has been recorded from Quebec, New Brunswick, and Newfoundland (Brown, 1940, p. 69; 1950, p. 198, DAO!); the first American specimen was taken in 1905 by Bolster at Codroy, Nfld. (MCZ!).

A. (*B.*) *apricaria* (Payk.).—Wolfville, Kings Co. (Fgn!); Truro (Lth.); North Sydney, C.B.I., abundant (Lth.).

A. (*B.*) *latior* (Kby.).—Annapolis Royal (Bwn., DAO!); Auburn and Wolfville, Kings Co. (Fgn!); Truro (Lth.).

A. (*Percosia*) *obesa* (Say).—Port Maitland, Yarmouth Co. (Bwn., DAO!); North Sydney, C.B.I. (Lth.).

?A. (*Celia*) *patruelis* Dej.—Wickham (1896, p. 39) reported "*interstitialis*" from Nova Scotia. If the locality is correct, the record must be referred to *patruelis*.

A. (*C.*) *bifrons* (Gyll.).—An European introduction, which is known in America only from Nova Scotia and Newfoundland (Brown, 1950, p. 198). It was first taken in America at Glace Bay, C.B.I., in 1929 (Fall Collection, MCZ!); Dartmouth (Brown, l.c.; DAO!). The species is a typical larval hibernator and was not observed in May, 1951.

A. (*s. str.*) *impuncticollis* (Say).—Queens Co. (MCZ!); Crescent Beach, Halifax, Truro (Lth.).

A. (*s. str.*) *cupreolata* Putz. (*neoscotica* Csy.).—Casey's single male type (NMW) agrees completely in genitalic and other characters with an original Putzey male of *cupreolata* from New Jersey in the LeConte Collection (MCZ). Casey's type is from Halifax.

A. (*s. str.*) *lunicollis* Schiöd. (*vulgaris auct., partim*).—Dartmouth (Brown, 1950, p. 199; DAO!); Halifax and Truro (Lth.); North Sydney, C.B.I. (Lth.). Probably introduced from Europe.

A. (*s. str.*) *familiaris* (Dft.) (*humilis* Csy.).—First taken in America at Weymouth in 1924 (Fall Collection, MCZ!); now generally distributed in the province and abundant (Brown, 1950, p. 199); north to Cheticamp and North Sydney, C.B.I. (Lth.). An European introduction.

A. (*s. str.*) *aenea* (Deg.) (*devincta* Csy.).—First taken in Nova Scotia on Cape Breton Island in 1931 (MCZ!). Now generally distributed; extremely abundant in the suburban streets of Halifax; north to Cape North. An European introduction (Brown, 1950, p. 199).

A. (*Zezea*) *pallipes* Kby.—Westchester Lake, Cumberland Co. (Fst., DAO!); Halifax (Evans, 1899, p. 321; Lth.); Orangedale and North Sydney, C.B.I., abundant (Lth.).

Rembus obtusus Lec.—Halifax, one example, and Truro, one example (Lth.). There seems little doubt that *parallelus* Csy. is a synonym.

Badister n. sp. (*pulchellus auct.*, *nec* Lec.).—Cheticamp, C.B.I., one example in the flooded delta (Lth.).

B. micans Lec.—Aylesford, Kings Co., Sept. 10, 1952, immature (Fgn!).

B. reflexus Lec.—Cheticamp, four examples on the flooded delta (Lth.).

Calathus gregarius Dej.—Cheticamp, C.B.I.; three examples, one with fully developed hind wings, on the seashore (Lth.).

C. ingratus Dej.—Kedgemakooge, Queens Co. (Ncy., AMN!); Truro (Fall Collection, MCZ!).

Synuchus impunctatus (Say) (*Pristodactyla impunctata*).—Portaupique, Colchester Co. (Fst., DAO!).

Pristonychus terricola (Hbst.).—This introduced species, known also from Quebec, New Brunswick, and Newfoundland, was first reported in America from an unknown locality in Nova Scotia (Hamilton, 1889, p. 159 and 1894, p. 354; Brown, 1940, p. 69).

Agonum (*Platynus*) *sinuatum* (Dej.).—Widely distributed and common (DAO!, MCZ!, NSM!, Lth.) but not reported from Cape Breton Island. Some specimens approach *decens* (Say) in the form of the prothorax.

A. (*P.*) *reflexum* (Lec.).—Annapolis Royal and Lake Rossignol, Queens Co. (Fgn!); Smith's Cove (Gibson, 1917, p. 146); Sackville (Lth.); Cape Breton Island (MCZ!).

A. (*Anchomenus*) *ruficorne* (Gze.) (*nec ruficorne* Lec., *albipes* Fab., *clemens* Lec.).—Bridgewater, on clayish river bank, four examples (Lth.); Halifax, Armdale, one example (Fgn!). The types of *clemens* were from Nova Scotia (MCZ!). Introduced from Europe and known also from New Brunswick (MCZ!, NMW!), Maine (NMW!), and Newfoundland (*vide* Brown, 1940, p. 70 and 1950, p. 199).

A. (*A.*) *elongatulum* Dej. (*extensicolle auct. partim*, *nec* Say).—Several localities (MCZ!, NSM!, Lth.), abundant at most, but unknown from Cape Breton Island.

A. (*s. str.*) *cupripenne* (Say).—Halifax (Evans, 1899, p. 321; Fgn!, Lth.); Three Brooks, Pictou Co. (Fgn!); Sydney, C.B.I., four examples (DAO!).

A. (*s. str.*) *Mülleri* (Hbst.) (*Hardyi* Lec.).—This European introduction is distributed over all of Nova Scotia to Cape North (Lth.). The earliest record, from Sydney, C.B.I., was made in 1890 (DAO!), but the species was taken in Quebec in 1881 and in Newfoundland in the decade following 1840.

A. (*s. str.*) *placidum* (Say).—Halifax (Evans, 1899, p. 321; DAO!, Lth.); North Sydney, C.B.I. (Lth.).

A. (*s. str.*) *octopunctatum* (Fab.).—Bridgewater, on the river bank, one example (Lth.).

A. (*s. str.*) n. sp.—Lapland,. Lunenburg Co. (Fgn!); Sackville, Waverley and Riversdale (Lth.); Orangedale, C.B.I. (Lth.). This species, externally, is almost identical with *fidele* Csy., but has quite different genitalia.

A. (*s. str.*) *mutatum* G. and H. (*atratum* Lec.).—Halifax (Lth.); North Sydney, C.B.I. (Lth.). Abundant where it occurs; in very wet moss, usually sphagnum.

A. (*s. str.*) *fidele* Csy. (*laeve* Lec., *molestum* Lec.).—Widely distributed but not abundant (DAO!, MCZ!, NSM!); north to North Sydney, C.B.I. (Lth.).

A. (*s. str.*) *metallescens* (Lec.) (*lacustre* Csy.).—Cheticamp and North Sydney, C.B.I. (Lth.); also "N.S." (MCZ!).

A. (*s. str.*) *carbo* (Lec.) (*affine* Kby. *nomen validum*).—Port Medway, Queens Co. (MCZ!); Sackville (Lth.); Port Wallis (Fgn!); Cheticamp and North Sydney, C.B.I. (Lth.).

A. (*s. str.*) *Harrisii* Lec.—Widely distributed and rather common, extending to Cape North, C.B.I. (Lth.). One example from "N.S." in the LeConte Collection is labelled "*?tenue*". LeConte (1879, p. 48) was wrong in placing *Harrisii* as a synonym of *affine* Kby. (*vide carbo* Lec.).

A. (*s. str.*) *melanarium* Dej.—Generally distributed and abundant (AMN!, NSM!, Lth.), extending to Cape North (Lth.).

A. (*s. str.*) *tenue* (Lec.) (*?moerens* Dej.).—Generally distributed and abundant (MCZ!, NSM!, Lth.), extending to Cape North (Lth.). The LeConte Collection (MCZ!) contains two examples from Nova Scotia labelled "*moerens* Dej." The male genitalia, however, seem identical in individuals which, according to external factors, should be referred to *moerens* viz. to *tenue*.

A. (*s. str.*) *propinquum* G. and H. (*piceum* Lec.).—"N.S." (LeConte Collection, MCZ!); Aylesford, Kings Co., September, 1952 (Fgn!).

A. (*s. str.*) *deceptivum* (Lec.).—Described from Nova Scotia and Lake Superior, the types in the LeConte Collection (MCZ!); Kedgemakooge, Queens Co., two specimens (Ncy., AMN!); Orangedale, C.B.I., May 28, 1951, at brackish water, one male unusually large, but with typical genitalia (Lth.).

A. (*Agonodromius*) *Bogemannii* (Gyll.) (*obsoletum* Say).—Halifax (Evans, 1899, p. 321, DAO!).

A. (*A.*) *quadripunctatum* (Deg.).—Cheticamp, C.B.I., one example on the seashore (Lth.).

A. (*Circinalia*) *aeruginosum* Dej.—Kedgemakooge, Queens Co., five examples (Ncy., AMN!); Bridgewater, two examples (Lth.).

A. (*Europhilus*) *Thoreyi* Dej. (*picipenne* Kby., *gemellum* Lec.).—Aylesford, Kings Co. (Fgn!); Waverley (Lth.); Baddeck, Cheticamp, and North Sydney, C.B.I., abundant (Lth.).

A. (*E.*) *gratiosum* (Manh.) (*lene auct.*, nec Dej.; *ruficorne* Lec., nec Gze.).—Westchester Lake, Cumberland Co. (Fst., DAO!); Yarmouth (Bwn., DAO!); Halifax (DAO!; Lth.). Generally distributed and extending to Cape North on Cape Breton Island (Lth.).

A. (*E.*) *retractum* Lec.—Kedgemakooge, Queens Co. (Ncy., AMN!); Boisdale, C.B.I. (Leng, AMN!).

A. (*E.*) *sordens* Kby. (*picicorne* Lec.).—Halifax, abundant (Lth.); Cheticamp, C.B.I., one example (Lth.).

A. (E.) dilutipenne (Mtsch.) (*picipenne auct., nec* Kby.).—Aylesford, Kings Co. (Fgn!); South Ohio (Bwn., DAO!); Halifax (Lth.); Baddeck, Cheticamp, and North Sydney, C.B.I. (Lth.).

A. (E.) lutulentum (Lec.).—Halifax (Lth.); Baddeck, Cheticamp, and North Sydney, C.B.I., abundant (Lth.).

A. (E.) n. sp.—Sackville River, May 20, 1951, one example (Lth.). This species, known also from Massachusetts and Connecticut, will be described in a paper dealing with the subgenus *Europhilus*.

A. (E.) consimile (Gyll.) (*invalidum* Csy.).—Cheticamp, Cape North, and Sydney, C.B.I.; abundant in very wet moss (Lth.).

Lebia viridis Say.—Bear River, Annapolis Co., Aug. 24, 1945, one example (Fgn!).

L. moesta Lec.—Halifax, two examples (DAO!).

L. pumila Dej.—St. Margaret Bay, Aug. 9, 1945, one example (Fgn!).

L. solea Hentz (*scapularis* Dej., *nec* Fourc.).—Yarmouth, July 2, 1947, one specimen (Bwn., DAO!).

L. canonica Csy.—Portaupique, Colchester Co. (Fst.; Brown, 1930, p. 151, "*ornata*", DAO!); Kentville, Kings Co. (Criddle, 1928, p. 93); Kedgemakooge, Queens Co. (Ncy., NMW!).

Dromius piceus Dej.—Ingramport, Halifax Co. (Bwn., DAO!).

Apristus cordicollis (Lec.).—Portaupique, Colchester Co. (Fst.; Brown, 1930, p. 151); Waverley (Fgn!); Riversdale, very abundant (Lth.); Cape North, C.B.I., two examples (Lth.).

A. subsulcatus (Dej.).—Cheticamp River, C.B.I., three examples (Lth.).

Microlestes ?linearis (Lec.) (*Blechrus lineáris*).—Halifax, one specimen (Lth.). This is *linearis sensu* Casey (1920, p. 269), but, whether it is LeConte's species, I am unable to decide. In the LeConte Collection, there are at least three species, including the type of *linearis*, under the name "*nigrinus* Mnh." The North American species are in need of revision.

Metabletus americanus (Dej.).—Halifax (Fgn!, Lth.); Truro (Lth.); north to Cape North, C.B.I. (Lth.).

Pinacodera limbata (Dej.).—Caledonia, Queens Co.; Halifax, abundant on sugar bait for moths (Fgn!).

Cymindis borealis Lec.—Described from Nova Scotia (LeConte, 1863, p. 7); Boisdale (Leng, AMN!) and Sydney (DAO!), C.B.I.

C. cribricollis Dej.—Cape Breton Island (Leng, AMN!), Sydney (DAO!).

Chlaenius alternatus Horn.—Annapolis Royal (Bwn., DAO!).

C. niger Rand.—Barrington, Shelburne Co. (MCZ!); Waverley (Lth.); delta of Cheticamp River, C.B.I., abundant (Lth.).

C. pennsylvanicus Say.—Port Wallis, Halifax Co., abundant (Fgn!); Orangedale, C.B.I. (Lth.); "N.S." (MCZ!).

C. tricolor Dej.—Weymouth, Digby Co. (Bls., MCZ!).

C. sericeus (Forst.).—Greenfield, Queens Co. (Bls., MCZ!); Halifax (Evans, 1899, p. 321); Sackville and Port Wallis (Fgn!); several localities north to Cape North on Cape Breton Island (Lth.).

C. (Brachylobus) lithophilus Say.—Waverley and Riversdale (Lth.); Cape North, C.B.I. (Lth.).

Anomoglossus emarginatus (Say).—Annapolis Royal (DAO; det. G. E. Ball).

Harpalus (Pseudophonus) pennsylvanicus (Deg.).—Queens Co. (MCZ!); Armdale, Halifax Co. (Fgn!); Truro (Lth.).

H. (P.) compar Lec.—Prospect Road, Halifax, Aug. 11, 1951, one example (Fgn!).

H. (P.) rufipes (Deg.) (*pubescens* Müll.).—First found in Nova Scotia in Kings County in 1938 (Morrison, 1941, p. 217); Truro (Lth.); generally distributed on Cape Breton Island north to Sydney and Cape North.

H. affinis (Schrk.) (*aeneus* Fab., *viridiaeneus* Beauv.).—Generally distributed and abundant (Evans, 1899, p. 321, DAO!, MCZ!, NSM!); north to Cape North (Lth.).

H. basilaris Kby.—Halifax, one example (Evans, 1899, p. 321, DAO!).

[*H. indigens* Csy. (Fst.; Brown, 1930, p. 151.—There are no examples at the Department of Agriculture, Ottawa or in the Frost Collection; the species should be omitted.]

H. pleuriticus Kby.—Generally distributed (Evans, 1899, p. 321, "*fallax*", DAO!; MCZ!; NSM!; Lth.); north to Cape North (Lth.).

H. herbivagus Say.—Portaupique, Colchester Co. (Fst., DAO!); Armdale, Waverley, and Sackville (Fgn!).

H. plenalis Csy.—Riversdale, three examples (Lth.); Cape Breton Island: Baddeck, one example (Fgn!), Cheticamp, one example, and North Sydney, two examples (Lth.).

H. Lewisi Lec.—Aylesford, Auburn, and Aldershot, Kings Co. (Fgn!).

Anisodactylus (Triplectrus) rusticus (Say).—Halifax (Evans, 1899, p. 321). No specimen has been seen, but there is no reason to doubt the identification.

A. (s. str.) Harrisi Lec.—Yarmouth, one example (Bwn., DAO!).

A. (s. str.) nigerrimus (Dej.).—Yarmouth (Bwn., DAO!), Halifax (Fgn!, Lth.).

A. (s. str.) nigrita Dej. (*interpunctatus* Kby.).—Aylesford, Kings Co., September 10, 1952, two examples (Fgn!).

A. (s. str.) n. sp. (*interpunctatus auct., nec* Kby.).—Riversdale, one example (Lth.); Port Wallis, Halifax Co., August 23, 1952, two immature examples (Fgn!); Cheticamp, C.B.I., two examples (Lth.). A new name will be proposed for this species in a forthcoming paper on Kirby's species of Carabidae.

A. (Xestonotus) lugubris (Dej.).—Halifax (DAO!), Sackville (Fgn!).

A. (Anadaptus) baltimorensis (Say).—Kentville, Kings Co. (DAO!).

Anisotarsus terminatus (Say).—Auburn, Kings Co., two examples (Fgn!).

Trichocellus cognatus (Gyll.) (*ruficrus* Kby.).—Yarmouth (Bwn., DAO!).

Tachycellus nigrinus (Dej.).—Widely distributed and abundant (DAO!; NSM!; Lth.; Brown, 1930, p. 151); Baddeck and North Sydney, C.B.I. (Lth.).

Bradycellus (Catharellus) Lecontei Cki. (*cordicollis* Lec.).—Kentville, Kings Co., and Yarmouth (Bwn., DAO!); Halifax (Lth.); Baddeck and Cheticamp, C.B.I., abundant (Lth.); "C.B.I." (MCZ!).

B. (Stenocellus) rupestris (Say).—Halifax, abundant, and Riversdale (Lth.); Orangedale and Baddeck, C.B.I. (Lth.).

B. (S.) neglectus (Lec.).—Several localities (DAO!, MCZ!, NSM!, Lth.); Orangedale, C.B.I. (Lth.).

Acupalpus carus (Lec.).—Medway, Queens Co. (Bls., MCZ!); Riversdale (Lth.); Baddeck and Cheticamp, C.B.I. (Lth.). Two specimens, unfortunately

females, from Cape North seem different and may be the *nanellus* of Casey. I was unable, however, to make the necessary comparison with the type. The genus *Acupalpus*, though small, is very difficult and is in need of a thorough revision.

A. canadensis Csy.—Orangedale, Baddeck, North Sydney, and Cape North, C.B.I., abundant (Lth.).

Stenolophus carbonarius (Dej.).—Waverley; one example of this characteristic species was taken in a *Typha* swamp but, unfortunately, escaped (Lth.).

S. fuliginosus Dej.—Widely distributed and often abundant (DAO!, MCZ!, NSM!, Lth.); north to Cheticamp and North Sydney, C.B.I. (Lth.).

S. ochropezus (Say).—Bridgewater, two examples on the river bank (Lth.); Armdale and Port Wallis, Halifax Co. (Fgn!).

S. conjunctus (Say).—Portaupique, Colchester Co. (Fst., Brown, 1930, p. 151, DAO!); Halifax (Lth.); Cheticamp, C.B.I., five examples (Lth.).

Agonoderus (*Tachistodes*) *pauperculus* (Dej.).—Yarmouth (Bwn., DAO!), Halifax (Bwn., DAO!; Lth.), Riversdale (Lth.).

Omophron americanum Dej.—Bridgewater and Riversdale (Lth.); North Cape, abundant (Lth.).

O. tessellatum Say.—Cheticamp, C.B.I., on the sandy border of a lagoon, very abundant (Lth.).

?*O. robustum* Horn (*brevipenne* Csy.).—Described from Nova Scotia (Horn, 1870, p. 73; one specimen in the LeConte Collection, MCZ!). Fall (1920, p. 211) doubts the correctness of the type locality.

References

Blackwelder, R. E. 1939. Fourth supplement to the Leng catalogue of Coleoptera of America, north of Mexico. John D. Sherman, Jr., Mount Vernon, N.Y.

Brown, W. J. 1930. The entomological record, 1929. Sixtieth Annu. Rept. Ent. Soc. Ontario (1929), pp. 146-157.

Brown, W. J. 1940. Notes on the American distribution of some species of Coleoptera common to the European and North American continents. *Canadian Ent.* 72: 65-78.

Brown, W. J. 1950. The extralimital distribution of some species of Coleoptera. *Canadian Ent.* 82: 197-205.

Casey, T. L. 1920. Memoirs on the Coleoptera, IX. The New Era Printing Co., Lancaster, Pa.

Casey, T. L. 1924. Memoirs on the Coleoptera, XI. The New Era Printing Co., Lancaster, Pa.

Criddle, N. 1928. The entomological record, 1927. Fifty-eighth Annu. Rept. Ent. Soc. Ontario (1927), pp. 92-103.

Darlington, Jr., P. J. 1933. The subspecies of *Sphaeroderus canadensis* Chd. *Psyche* 40: 62-64.

Darlington, Jr., P. J. 1938. The American Patrobini. *Entomologica Americana* 18: 135-183.

Evans, J. D. 1899. List of Coleoptera from Halifax, N.S. *Canadian Ent.* 31: 320-321.

Fall, H. C. 1920. New Coleoptera, IX. *Canadian Ent.* 52: 211-215.

Fall, H. C. 1922. Notes on *Clivina*, with description of a new species from the Pacific Coast. *Ent. News* 33: 161-164.

Fall, H. C. 1934. A new name and other miscellaneous notes. *Pan-Pacific Ent.* 10: 171-174.

Fletcher, J. 1905. Entomological Record, 1904. Thirty-fifth Annu. Rept. Ent. Soc. Ontario (1904), pp. 56-78.

Gibson, A. 1917. The entomological record, 1916. Forty-seventh Annu. Rept. Ent. Soc. Ontario (1916), pp. 137-171.

Hamilton, J. 1889. Catalogue of the Coleoptera common to North America, Northern Asia and Europe, with the distribution and bibliography. *Trans. American Ent. Soc.* 16: 88-162.

Hamilton, J. 1894. Catalogue of the Coleoptera common to North America, Northern Asia and Europe, with distribution and bibliography; second edition. *Trans. American Ent. Soc.* 21: 345-416.

Harris, E. D. 1911. North American cicindelas in the Harris Collection. Yonkers, N.Y.

Hayward, R. 1897. On the species of *Bembidium* of America north of Mexico. *Trans. American Ent. Soc.* 24: 32-143.

Hayward, R. 1908. Studies in *Amara*. *Trans. American Ent. Soc.* 34: 13-65.

Horn, G. H. 1870. Contributions to the coleopterology of the United States. *Trans. American Ent. Soc.* 3: 69-142.

Horn, G. H. 1875. Synonymical notes and descriptions of new species of North American Coleoptera. *Trans. American Ent. Soc.* 5: 126-197.

Horn, G. H. 1882. Synoptic tables of Coleoptera. *Bull. Brooklyn Ent. Soc.* 5: 47-48.

Jones, J. M. 1869. Nova Scotian Coleoptera. *Proc. and Trans. Nova Scotian Inst. Nat. Sci.* 2: 141-155.

LeConte, J. L. 1863. New species of North American Coleoptera. *Smithsonian Misc. Coll.* 167: pp. 1-86.

LeConte, J. L. 1879. Synopsis of the N.A. species of *Platynus*, Bon. *Bull. Brooklyn Ent. Soc.* 2: 45-58.

Leng, C. W. 1920. Catalogue of the Coleoptera of America, north of Mexico. John D. Sherman, Jr., Mount Vernon, N.Y.

Lindroth, C. H. 1940. Zur systematik fennoskandischer carabiden. 4-12. *Bembidion*-studien. *Notulae Ent.* (1939) 19: 63-99.

Morrison, F. O. 1941. Imported carabid beetle may be a potential pest. *Canadian Ent.* 73: 217-218.

Vaurie, P. 1951. Five new subspecies of tiger beetles of the genus *Cicindela* and two corrections. *American Mus. Novitates* 1479.

Wickham, H. F. 1896. Preliminary handbook of the Coleoptera of north-eastern America. *Jour. New York Ent. Soc.* 4: 33-49.

The Metamorphosis of the Pine Leaf Miner (*Exoteleia pinifoliella* (Chamb.)) (Lepid. Gelechiidae)

By WM. H. BENNETT

State University of New York
College of Forestry

The pine leaf miner (*Exoteleia pinifoliella* (Chamb.)), a native insect attacking several species of thick-needled pines (1), is generally distributed throughout the Atlantic States from Southern Ontario (4) to Georgia (3). In the vicinity of Syracuse, N.Y., there is but one generation a year. The insect overwinters in the larval form, begins pupation in early May, and flight and oviposition take place a month later.

Three to six needles are at least partly mined by each larva during its development. Typically the last-instar larva enters a needle on the flat surface approximately 30 mms. from the tip (1). A narrow tunnel is at first directed apically, but soon most of the inside tissue is consumed. Excrement is pushed from the entrance, and the dark-brown, 6-mm. long larva becomes visible through the translucent needle wall.

As soon as the mine has been completed, the larva proceeds to enlarge the entrance into a D-shaped hole extending the width of the needle. The opening is quickly covered with a sheet of silk. In a matter of seconds, layer after layer of closely placed strands are deposited. The completed covering, although transparent under the microscope, appears as a shiny, white spot to the unaided eye.

To facilitate the exit of the adult, the larva then lines the sides of the tunnel with silk and covers the green tissue at the basal end with a sloping silken mat (see figure). Fresh particles of excrement are packed toward the needle tip and eventually closed off by a partition of silk. After a prepupal period approximating a day, the larval exuviae are shed and remain attached to the silk at the end of the mine.

The 4 to 5 mm. pupa is elongate, cylindrical and shiny, dark brown to almost black. The helmet-shaped frons has a distinct raised point, situated dorso-anteriorly on its surface. The abdomen is movable between segments 6 and 7, and 7 and 8. The 10th segment bears a cremaster of minute, bright-yellow, apically-curved hooks (2).

Dorso-ventral wiggling of the pupa is a common occurrence and may be stimulated by the motion of the foliage in a light wind. During the movement, the cremaster becomes entangled in the surrounding silk and holds the pupal exuviae in place at ecdysis.

As the moth moves toward the exit, the helmet-like frons of the pupa splits but adheres to the delicate head. The raised point at the peak cuts a slit through the silk door and, with the guidance of the sloping mat, the moth quickly escapes. The protective cap is instantly discarded and becomes fastened to the silk at the edge of the hole.

The imago is active from the start and is capable of running, jumping or even flying, a few seconds after emergence.

References

(1) Bennett, Wm. H. (1954). The effect of needle structure upon the susceptibility of hosts to the pine needle miner (*Exoteleia pinifoliella* (Chamb.)). (Lepid. Gelechiidae). *Can. Ent.* (Feb.).

(2) Bennett, Wm. H. (1954). The pupal morphology of the pine needle miner. *Proc. Ent. Soc. Wash.* (Feb.): 41.

(3) Comstock, H. H. (1880). The pine leaf miner (*Gelechia pinifoliella* Chamb.) *Rept. of the Entomologist, U.S.D.A.,* Rept. for 1879; 238-241.

(4) Swaine, J. M. (1913). The pine leaf miner (*Paralechia pinifoliella* (Chamb.)). Notes on some forest insects of 1912. *43d. Ann. Rept. Ent. Soc. Ontario:* 90.

(Received March 12, 1954)

Atmospheric Circulation Processes and Insect Ecology[1]

By W. G. Wellington[2]

There are many papers on the effects of meteorological factors on insects, but only a few state these effects in terms of large-scale weather processes. Even fewer report the logical conclusion of such studies: prediction of the biological phenomena with the aid of modern methods of weather analysis and forecasting.

It is true that preliminary investigations of the effects of single factors are essential. Nevertheless, final reports often would be more valuable if they also showed how the different kinds of weather systems were involved in the relationships observed. To accomplish this, it is necessary to have some knowledge of the ideas behind modern methods of weather analysis and forecasting, particularly those concerned with air masses and frontal systems. Even now, these concepts are not as familiar as they should be, and the importance of their implications to insect ecology has not been seriously considered. Consequently, this paper has been written to show how these concepts, together with ideas concerning the dynamic aspects of climate, may be applied in ecological investigations.

In the space available, it is impossible to give much of the necessary meteorological background. Instead, references are cited that will serve as supplementary reading, and these are listed in the order of their increasing complexity (33, 25, 12, 5, 20). The circulation processes that are involved in weather production have both meteorological and climatological aspects that can be applied in ecological research, so that the paper logically divides into two parts.

AIR MASSES AND FRONTAL SYSTEMS

General Considerations

In certain parts of the general circulation, the movements of the major air currents often result in air remaining over a surface for a period sufficient to produce equilibrium between the lower levels of the air and the surface. If the surface is uniform over vast distances, as it is in parts of the polar, desert, or oceanic regions, large masses of the overlying air tend to acquire relatively uniform horizontal distributions of temperature and humidity. Such bodies of air are known as *air masses,* and the regions where they are produced are known as *air-mass source regions.*

There are arctic, polar, and tropical sources which produce corresponding types of air masses, and these masses may develop over either maritime or continental areas. Therefore, their distributions of temperature and humidity may vary considerably. Nevertheless, air from one type of source tends to be restricted in its variability with respect to these elements, so that each type of air mass can be readily identified by its source characteristics.

It is customary to refer to air masses by code letters describing their source regions, and by additional code letters indicating their maritime or continental origin. For example, air from polar sources may be designated either mP or cP, and that from tropical sources, mT or cT.

Fig. 1 shows most of the North American air-mass types and the approximate locations of their source regions. Ordinarily, air-mass sources are illustrated on a hemispheric scale, and it is customary to show transitional source regions and

Fig. 1. A simplified presentation of the approximate source regions of most of the air masses influencing North American weather and climate. Polar air masses (P) are shown by open arrows, and tropical air masses (T) are shown by black arrows. Both maritime (m) and continental (c) types are shown. From left to right, the polar air masses include polar maritime of Pacific origin (mP (Pacific)), polar continental (cP) and polar maritime of Atlantic origin (mP (Atlantic)). Similarly, tropical air masses include tropical maritime of Pacific origin (mT (Pacific)), tropical continental (cT) and tropical maritime of Gulf and Atlantic origins (mT (Gulf) and mT (Atlantic)).

seasonal changes in the locations of the major sources. Since Fig. 1 is over-simplified in these respects, readers interested in more complete illustrations should consult those of Petterssen (25) or of Berry and Bollay (4).

In Fig. 1, the open arrows indicate types of polar air, and the black arrows show tropical air. Arctic air and transitional types are not shown. The arrows show the approximate directions by which the air masses leave their sources, but they are not intended to indicate precise trajectories. Reading from left to right, the types of polar air illustrated include polar maritime of Pacific origin, polar continental, and polar maritime of Atlantic origin. Of these, the first two are more important to North American weather and climate. Similarly, the tropical air masses include tropical maritime air of Pacific origin, tropical continental air, and tropical maritime air of both Gulf and Atlantic origins. Of these types, the Pacific air is seldom important on even a subcontinental scale. The others are of varying importance in different parts of the continent.

Since any one of these air masses carries with it characteristic properties when it leaves its source region, a recognizable range of *air-mass weather* occurs within it. This weather persists in recognizable form even after the air undergoes considerable modification, a process which varies in degree, depending upon both the direction and the speed of travel of the air. Thus, cP air, which is dry and cold in its source region, may become somewhat moister and warmer as it moves southeastward through Canada but, in general, it will remain recognizably drier than any other type of air that invades eastern Canada.

It is not so easy to generalize about mP (Pacific) air, which dominates the weather of the west coast, and remains important over much of the rest of the continent. Its temperature and humidity vary in relation to its previous trajectory, even on the west coast and, often, after it has crossed the mountains, it is almost as dry as modified cP air.

Tropical maritime air remains warm and moist even after considerable modification. In Canada, it is most important in eastern regions. North and west of Lake Superior, it becomes less and less important, and its function is fulfilled either by mP air that first entered the continent far south of the Canadian border before recurving northward, or by cT or transitional air from the Great Basin or the Southwest.

Tropical continental air is a product of the arid southwestern part of the continent, and originates there chiefly during summer months, although it sometimes occurs during spring and autumn. It is seldom discussed in detail in texts on North American meteorology, because mT air is so impressively predominant throughout the eastern part of the continent. It will become clear in subsequent diagrams, however, that central Canada is often profoundly influenced by this air or its transitional subsidiaries, so that it is worth more attention. It and its subsidiaries are usually considered to be hot and dry but, by the time they have entered Canada, they sometimes seem more humid and often feel like greatly modified mT air to an observer who lacks maps to trace their origin.

The transition from the characteristics of one type of air mass to those of another is generally abrupt, and zones of discontinuity are readily detectable along the borders between air masses. Along these borders, areas of low pressure often form, and the parts of the zones of discontinuity associated with these cyclones frequently develop into active *frontal systems*, which have types of weather that differ markedly from any air-mass weather found on either side of a frontal surface. *Frontal weather* produces changes that are more marked, but also more transient than those associated with air-mass weather. Characteristically different types of frontal weather are associated with *warm fronts*, where warm air replaces cold air at the surface, and with *cold fronts*, where the opposite change occurs. Both types of weather are of considerable ecological interest, but most of the subsequent examples are concerned with the effects of cold fronts.

When cold air replaces warm air, the frontal surface formed is generally much steeper than a warm frontal surface, and this added steepness produces an exceptionally violent reaction in the warm, moist air that is lifted ahead of the oncoming cold air. Convective clouds rise to great heights, and showery precipitation is usually produced. Sometimes there is also an instability line of additional convective activity formed several miles in advance of the main frontal surface.

Fronts and Insect Activity

Fig. 2 is a simplified version of one of the synoptic charts showing surface conditions for July 21, 1946. Winds and station details have been omitted because of the reduced scale. Despite these omissions, the chart shows the possible extent of cyclones and anticyclones, a point which is of importance in the second part of this paper, and also shows their associated frontal systems. In addition, the black arrow extending from the vicinity of Lake Nipigon to the north shore of Lake Superior shows the course of a flight of spruce budworm moths that was first observed at Port Arthur, Ontario.
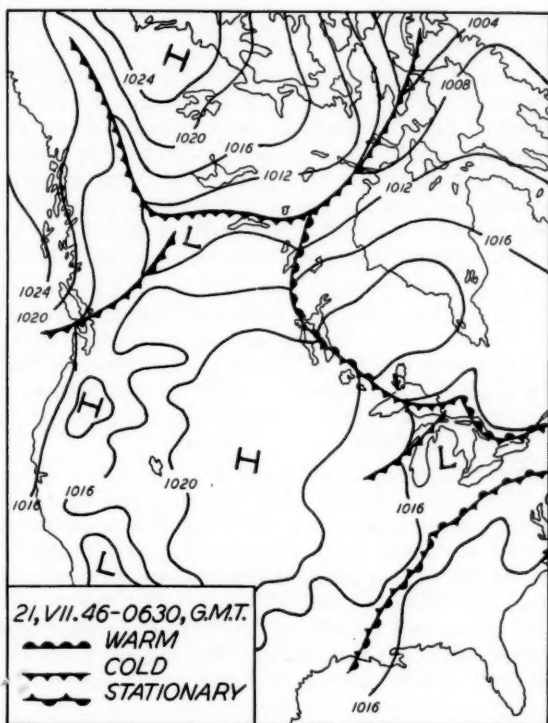
Fig. 2. A partially complete synoptic chart for July 21, 1946, 0630 hrs., G.M.T. The map includes isobars showing the pressure pattern at four-millibar intervals, and enclosing the regions of high and low atmospheric pressure at the surface. Complex frontal systems are shown, and the black arrow between Lake Nipigon and Lake Superior shows the course of a group of spruce budworm moths transported from the infestation near Lake Nipigon to Port Arthur, Ont., by convection associated with the cold front that is shown over Lake Superior at map-time.

This is an example of an association between mass flights* of the spruce budworm and passages of cold fronts first reported by Henson (10) and since confirmed on several occasions in New Brunswick by D. O. Greenbank (as yet unpublished).   Typically, great numbers of moths of both sexes suddenly appear during the night in a locality far removed from their nearest possible source, and their appearance is always associated with the subsequent passage of a cold front or its instability line.   (In the example, the cold front involved had moved out over Lake Superior by map-time.)

This example suggests one way in which weather forecasts may be of direct service in an ecological problem, when an observed association between mass depositions of insects and approaching fronts is so consistent. When careful studies of population trends of an insect known to be susceptible to transport are in progress, it would be worth while to arrange for warnings of approaching

*The term, *mass flight*, is not considered a suitable description of the phenomenon, since it implies a more active contribution on the part of the transported moths than actually occurs. D. O. Greenbank has suggested *convective transport*, and this term gives a more accurate impression of the process involved.

cold fronts, so that subsequent sudden population increases in restricted areas could be properly evaluated.

Other examples of an association between insect activity and cold frontal passages were pointed out by Lewis (18) in an unpublished thesis describing the effects of weather on daily variations in the abundance of insects collected in a rotating net near the ground. During this investigation, the usual meteorological records were accumulated, but the passages of frontal systems were also recorded, and helped to clarify some of the effects of combined variations in temperature and atmospheric pressure upon the daily collections. Table I contains data extracted from the original report, and shows some of the relationships observed.

In the table, the frontal passages have been divided into two groups on the basis of the part of the day in which a front passed over the station. As a front approaches, the pressure falls. The collections were made during daylight, so that it is clear that during the day of frontal passage, those of Part A had to be made during the prefrontal fall in pressure, whereas those of Part B were always made while the pressure was fluctuating near the time of passage, or while it was rising after the front had passed.

In his accompanying text, Lewis noted the importance of variable temperature, but pointed out that it was also clear that the prefrontal fall in pressure was associated with increased numbers of insects caught, whereas the postfrontal rise was associated with decreased catch, whether or not the change in temperature was significant. In the present example, this is shown particularly in the second record of Part A, and in the last two of Part B, where the temperature changes between the day before and the day of frontal passage were unimportant, but the pressure trends influenced the catches. The second front in Part A was a very weak cold front, and the last two in Part B were quasistationary fronts.

TABLE I

Daily Variations in Numbers of Insects Caught in a Rotating Net in Relation to
Passages of Cold or Quasistationary Fronts
(Adapted From Lewis, 1950)

	Day before frontal passage	Day of frontal passage	Pressure trend during collection period through:	
			Day before frontal passage	Day of frontal passage
A. When Fronts Passed after 2000 hrs.				
Total Catch............	120	205	Falling	Falling more rapidly
T *mx*, °F...............	85	82		
Total Catch............	98	142	Falling	Falling then fluctuating
T *mx*, °F...............	79	79		
B. When Fronts Passed before 2000 hrs.				
Total Catch............	217	128	Falling	Rising
T *mx*, °F...............	100	75		
Total Catch............	176	106	Falling	Rising
T *mx*, °F...............	93	78		
Total Catch............	172	136	Falling	Rising
T *mx*, °F...............	82	81		
Total Catch............	233	209	Falling	Fluctuating then rising
T *mx*, °F...............	88	88		

Once again, these examples suggest that it should be possible to develop a system for predicting short-term changes in insect activity or abundance based on regular forecasting methods. Furthermore, such a system should be easier to use and, in the long run, should yield more accurate indications of approaching changes in trends, than predictive systems developed from studies of the effects of ordinary meteorological factors. In addition, if data were collected with due regard for the passages of fronts, the controversy over the effects of high and low pressure on insect activity (35) finally might be settled.

An interesting example of how modern methods of weather analysis can be used in ecological studies was reported recently by Rainey (27). Combination of meteorological records with reports of changes in the locations of major swarms of locusts in East Africa, Arabia, and the Indo-Pakistan region showed that the swarm locations changed as the Intertropical Front shifted. This led to the suggestion that, within range of the Intertropical Convergence Zone (and possibly elsewhere), major swarm movements take place towards, and with, zones of convergence. Apart from noting its obvious forecast value, Rainey pointed out that this hypothesis could provide a background against which the finer effects of behaviour on displacement may be studied more successfully, and this comment applies with equal force to all the preceding examples.

Each of the preceding examples was concerned with variations in insect activity in response to different weather conditions, and each demonstrated the progress that could be made in research carried out against the background of present-day ideas about weather. On the other hand, these examples should have made it equally clear that the methods developed with these ideas in mind can be used to predict biological events with some accuracy as long as a weather relationship can be demonstrated, even while information about the exact stimuli involved in the activity is lacking. The next example shows how a knowledge of air masses and fronts may be used in problems that do not directly involve activity, and in which the causative factor is known.

Air-mass Climatology and Insect Mortality

In the Bow Valley of Banff National Park, the amount and upslope distribution of the mortality of overwintering larvae of the lodgepole needle miner vary annually, depending on the type of winter weather that occurs (11). There has never been any doubt that low temperatures were responsible for the mortality, but ordinary meteorological records alone have not always provided a reasonable explanation of the changing distribution of mortality. To interpret observed distributions, it was necessary to make firsthand studies of the effects of the surrounding mountainous terrain on passing frontal systems, and to determine the different frequencies of occurrence of fronts and air masses over the areas during two winters that showed particularly interesting distributional differences.

In the Bow Valley, cold frontal passages at any time produce lower temperatures on the upper slopes than in the valley bottom but, if the invading cP air stagnates over the valley, the temperatures at the two levels first approach equality, and then reverse. This change in temperature distribution with time is the result of excessive radiant cooling through the clear, stagnating air. If the air stagnates for many days, radiant cooling not only lowers the temperatures at all elevations, but also forms an inversion in which temperature increases, instead of decreasing, with height.

During the first winter, mortality was light in the valley bottom, but increased upslope. During the coldest month of this winter, frequent cold

fronts passed over the valley, so that no new invasion of cP air remained for many days. Consequently, the slopes were more often colder than the valley bottom, particularly in the sheltered main trench, and this accounted for the increase in mortality with height.

During the second winter, mortality was much heavier, but tended to decrease slightly with height. In the coldest month of this winter, the amount of frontal activity was much reduced, so that cold cP air that invaded the area stagnated over the valley for long periods. The air was cold, and excessive radiation made it colder. The prolonged exposure to extremely low temperatures which overwintering larvae experienced during this period of stagnation was sufficient to account for the general increase in mortality. In addition, the pronounced temperature inversion over the valley accounted for the decrease in mortality with height that was observed in the sheltered main trench.

Although this analysis had a strong climatological bias, employment of air-mass and frontal analyses enabled the authors to develop a predictive system for use in future mortality and population studies. For example, one of the more interesting implications is that the heaviest persistent infestations should always be centered in the middle range of altitudes in the Bow Valley, because populations above or below this middle zone that might increase during a few favourable years should eventually suffer during the types of winter weather noted above. The predictive system now available will enable investigators to forecast the probable ultimate distribution of mortality before a winter ends, and recognition of the existence of a middle-zone reservoir should influence the course of future control measures. Thus, employment of air-mass climatology may permit development of systems of forecasting abundance or mortality on a seasonal basis. In the next section, the value of such a climatological approach to longer-term population problems is examined in greater detail.

CLIMATIC VARIATIONS AND CHANGES IN THE PATHS OF CYCLONIC AND ANTICYCLONIC CENTERS

General Considerations

Most of the familiar climatological methods were developed to determine average conditions over long periods, or to determine spatial distributions of single elements. They have served these purposes very well but, in addition, the types of results they have produced often have given the impression that climate changes little or not at all, and that any fluctuations observed in it are simply random fluctuations about a mean. Recently, however, evidence of a real climatic change finally accumulated to the point where the observed trend could no longer be attributed entirely to random fluctuations (1, 2, 6, 7, 13, 21, 26, 39, 40, 41). It was possible to show that the climate of northern regions became appreciably warmer, particularly between the latter decades of the nineteenth century and about 1940, than it had been since before the climatic deterioration that reached its peak during the thirteenth and fourteenth centuries.

Climatic changes of such long duration are of little direct interest to population ecologists, but the mounting evidence that some of their governing factors may be similar to those directly associated with daily or weekly weather changes (39) has implications that should be of direct interest. For example, if there were more real order to climatic variations 20 years or less in duration than was hitherto supposed, climate might be given more consideration in theoretical discussions of factors influencing oscillations in insect populations than it has been

accorded in the past.   In this section, some examples are given that may help
population ecologists to assess the amount of order in short-term variations.
(*Order* here connotes a more or less orderly trend, e.g., from a period during
which four out of five summers may be "wet" through an intermediate period
to another during which three or four out of five summers may be "dry".   Con-
sequently, it is neither necessary nor even desirable at present to postulate the
existence of the familiar, rigidly cyclical component.)

The examples presented once more require preliminary consideration of
essentially dynamic phenomena in which the general circulation of the atmosphere
is involved.   This has made it difficult to select a suitable method of presentation.
Ideally, the simplest approach, and the one of most value to ecologists, would
be to present records of the movements of air masses on a daily basis for several
decades, so that the fluctuations in their numbers and paths not only could give
a picture of the surface circulations involved in climatic variations, but also could
supply records directly applicable to ecological investigations.   This ideal will
be easier to attain about a decade hence, when series of the proper charts are
longer.   Now, unfortunately, most are too brief, and even they are relatively
inaccessible.

Again, accepted methods of dealing with the general circulation require
extensive use of upper-air data, but charts illustrating circulation patterns in the
upper air are even less meaningful to a general reader than are most meteor-
ological charts.   Consequently, it has been necessary to adapt or develop some
indirect methods to present examples in terms of surface phenomena that may
be linked with upper-air events on the one hand, and synoptic charts on the other.
Because they are indirect, their value is limited.   Some are valuable in historical
ecological surveys that must be extended back to the early years of the century.
All are adequate for illustrative purposes such as those of the present paper, since
they are slightly easier to follow than any methods based on sounder concepts,
such as the currently popular zonal index (cf. 22, 28).   None is even adequate
as a substitute for the more acceptable meteorological methods.   Therefore, they
must always be used with care, and should never be used if data on air masses
and fronts are available.   Their chief advantage at present is that they employ
records that are easily obtained, so that anyone who wishes can reproduce the
results.   Those who wish to obtain more acceptable background information
necessary for active work in the field will find it in the following references, or
in further references listed in them (5, 12, 20, 22, 24).

Changes in Direction and Numbers of Pressure Centers

For many years, the United States Weather Bureau has published monthly
charts in the *Monthly Weather Review* that show the paths of the centers of all
cyclones and anticyclones observed during the month.   The dates of origin and
the 12-hourly positions of the centers are also indicated on the arrows drawn
to show the paths.

Fig. 3 shows four diagrams illustrating tracks recorded during different parts
of the month of December, 1951.   This month was selected because the *Monthly
Weather Review* contains an especially complete discussion of its weather in
terms of upper air conditions (14).

The first two diagrams of Fig. 3 were constructed by tracing from the
original charts only those tracks of centers that originated during the first eight
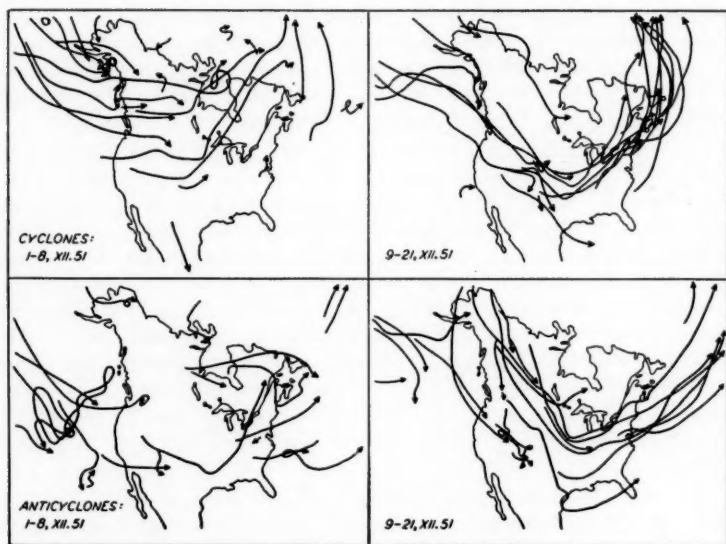days of the month.   All these were traced, whether or not they continued to exist

Fig. 3. Tracks of cyclonic and anticyclonic centers traced from the original charts of the *U.S. Weather Bureau Monthly Weather Review* for December, 1951. The left-hand pair of diagrams shows the lack of order in the paths of centers of both types during the period December 1-8. The right-hand pair shows the definite order that appeared among the paths of both types between December 9 and 21. This change shows the linkage of surface phenomena with changes in the upper winds, notably those of the jet stream.

after December 8. The last two diagrams, for the period December 9-21, were constructed in the same way. Tracks that began after December 21 were distributed in a way that required an additional pair of diagrams, so they have been omitted to save space. Unfortunately, it is impossible to show either the dates of origin or the 12-hourly positions of the centers at such a reduced scale.

Inspection of the pairs of diagrams shows that there was very little order to the directions of the tracks during the first eight days of the month. This is especially true of the tracks of anticyclonic centers. After the first eight days, however, definite order appeared among the directions of tracks of both types of centers. Both types had patterns that were very similar, although not entirely so.

Fig. 3, examined in relation to the discussion of the weather for December, 1951, in the *Monthly Weather Review* (14), shows in greater detail and in a more spectacular way the association of the main storm track with the position of the *jet stream*, the meandering belt of high-speed, high-altitude winds recently discovered (3, 23, 28, 32), and currently the subject of intensive study. When the jet stream is well-developed, neither cyclones nor anticyclones seem to cross it but, instead, tend to move along its edges. Consequently, the paths of their centers, even at the surface, tend to outline the shape of the jet stream, and give some indication of its latitudinal variation. This is shown by both types of tracks during the period December 9-21, 1951. The tracks for December 1-8 show the chaos resulting from the absence or weakness of the jet during at least part of that period. Consequently, Fig. 3 shows that collections of the tracks of

centers of pressure systems may bear a relatively trustworthy relationship to less abstract data associated with general circulation phenomena.

Because of this relationship, such tracks can be used to bridge part of the gap between original synoptic charts and upper-air data, as long as certain reservations are kept in mind.   For example, examination of the monthly collections of tracks, particularly those of cyclonic centers, shows not only that the whole complex tends to shift in position from month to month, or from year to year, but also that the complex is made up of natural groupings that appear to be closely linked with the source regions shown in Fig. 1.   Such groupings are easy to observe, but their existence does not mean it is correct to assume that any track is the path of *only* one air mass from its source region, because cyclones that contain frontal systems also must contain parts of one or two other air masses that originated in other source regions.   Nevertheless, it is correct to assume that most tracks that originate in known source regions contain *one* air mass that is typical of the source (cf. 36).

When only one group is considered at a time, it is possible to observe monthly or annual shifts in its position that are often obscured when the whole complex is considered.   Furthermore, when only one group is considered, the numbers of tracks are reduced to the point where it is possible to add tracks from two or three consecutive months for two or three successive years, whenever such consolidation seems advisable.   This cannot be done with the whole complex of tracks, because the resulting tangle completely obscures any shifts that might have occurred.   Finally, proper attention to isolated groups of tracks originating
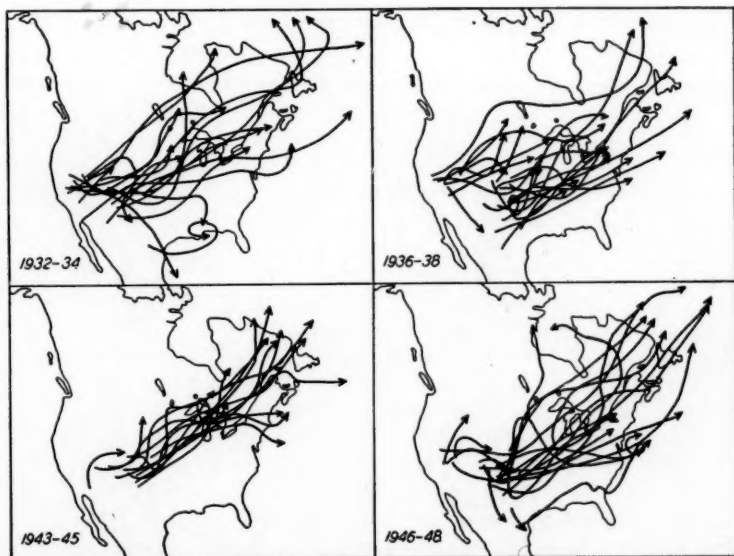

Fig. 4.   Tracks of cyclonic centers originating south of 40°N., between 100-120°W.   In this and in Figs. 5-6, tracks for the months of May, June and July were grouped together for each of the three-year periods shown.   In order to observe changes in the position of a group from diagram to diagram, select prominent features, such as the Great Lakes or the Gulf of St. Lawrence, to simplify comparisons between diagrams or between figures.   (N.B.—Figs. 4-6 should be examined together.)

in restricted areas is the answer to the trenchant and justifiable criticism levelled at earlier storm-track studies several decades ago (9), when tracks from all regions commonly were grouped together to determine belts of maximum frequency supposed to have some forecasting value.

Some examples of treatment of the original data by region and by consolidation of several periods are shown in Figs. 4-6. Each of these figures consists of a set of four diagrams depicting shifts in position exhibited by a group of tracks originating in a particular source region. Since May, June, and July are months that are especially interesting to entomologists, they have been used in the illustrations. To conserve space, the tracks for all three months have been consolidated. Since the summer solstice occurs in late June, and early May is farther removed from this point than late July, such grouping is not an entirely satisfactory procedure, and it is not recommended for intensive studies. For these, it is best to use a single month. To save additional space, further consolidation has been carried out by grouping these three-month units for three successive years. When the figures are compared, Figs. 4 and 5 should be considered together, and Fig. 6 forms another natural group.

Figs. 4 and 5 were constructed by tracing only those tracks of cyclonic centers that originated south of 40°N. This effectively disposed of most of the scattered cyclones formed in the nearby transitional zone, and of all of those formed at high latitudes. Fig. 4 contains only centers that originated between 100 and 120°W., whereas Fig. 5 contains those that originated east of 100°W. These final restrictions eliminated a few centers from the Pacific, but they separated the groups of tracks from the two major tropical source regions very well. For example, Fig. 4 shows centers that originated almost entirely within the cT source in Fig. 1, whereas the majority of the centers in Fig. 5 originated
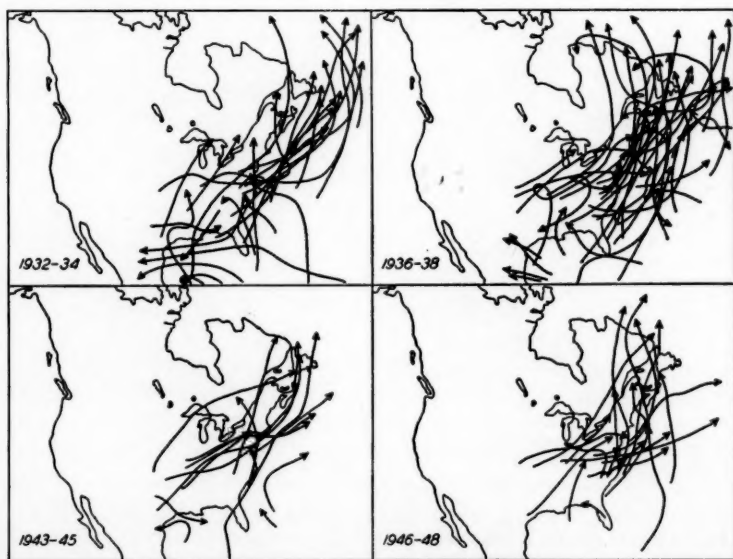

Fig. 5. Tracks of cyclonic centers originating south of 40°N. and east of 100°W. during May, June and July (cf. Fig. 4, particularly).
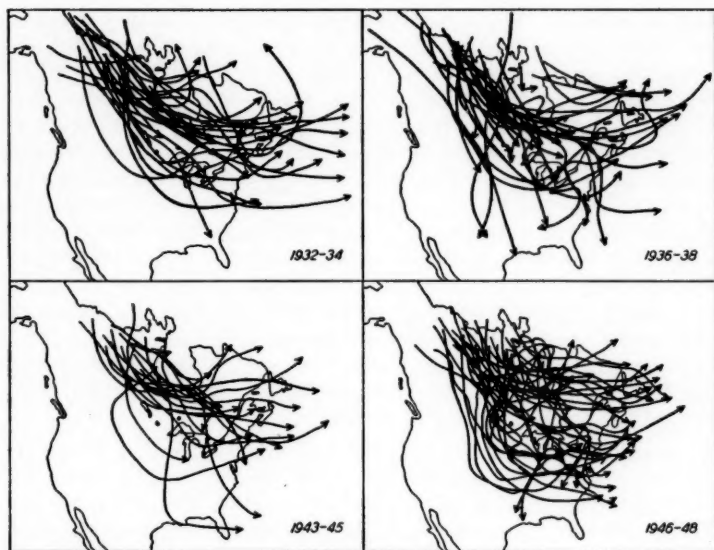
Fig. 6.   Tracks of *anticyclonic* centers originating north of 60°N., with no meridional restrictions, during May, June and July.

within the mT Gulf and Atlantic sub-sources shown in Fig. 1.   Only a few tracks occur that are transitional in origin, and most of these appear in Fig. 5. In these and subsequent figures, prominent features, such as the Gulf of St. Lawrence or the Great Lakes, provide check points for comparing shifts in position of a group from one diagram to the next.

In Fig. 4, the group originating in and around the cT source shows shifts in position between any two of the groups of years, but the most obvious feature is that, during 1932-34 and 1943-45, the tracks, *as a group*, were north of their positions during 1936-38 and 1946-48.   In addition, in the latter two groups of years, the general area of origin was shifted farther east-southeastward some 300-400 miles.

The same pairs of diagrams in Fig. 5 require somewhat closer inspection, but it can be seen that, in 1932-34 and 1943-45, most of the centers that had long over-water paths did not recurve towards or over the continent until north of the New England States and the Maritime Provinces.   In contrast, during 1936-38 and 1946-48, more centers with long over-water paths recurved towards the contingent before or by the time they reached these regions.   Therefore, in this sense, the mT group exhibits the same types of shifts as the cT group.

Fig. 6 contains tracks of *anticyclonic* centers.   Only those originating north of 60°N. were included, but no meridional restrictions were imposed.   Consequently, the centers shown are almost entirely of cP origin, with a few arctic centers included.   The diagrams for 1936-38 and 1946-48 show more frequent deep southern penetration then than during the other periods, and illustrate another form of the north-south shift shown in the two preceding figures.

Together, the three figures show that there was a northward shift of the whole complex during 1932-34 and 1943-45, and a southward shift during

1936-38 and 1946-48. They also show that groups of centers originating in different source regions behaved more or less as discrete units, with each source group retaining its own peculiarities during the latitudinal shifts. The year-groups illustrated were chosen because they were recent periods during each of which extreme positions occurred at least once. During intermediate periods, groups of tracks most frequently exhibited intermediate positions, a fact that can be checked readily enough by selecting any one month and inspecting its original charts for each year of a 10- to 20-year period. Similarly, recurring changes in position may be traced through the 1920's or earlier decades, but they then show most clearly for the southwestern cyclonic centers of Fig. 4 because, prior to 1930, the map area did not extend far above 55°N.

The periods 1932-34 and 1943-45 center on years of sunspot minima, and the other two center on sunspot maxima. Furthermore, the northward shifts around the minima and the southward shifts around the maxima observed during the 1930 and 1940 decades also hold for the southwestern cyclones, at least, during the solar minimum and maximum of the 1920 decade.

The regularity implied by this is of little ecological value, because of two other phenomena that may be observed in the figures. In Fig. 4, for example, the 1946-48 group, although undeniably south of the two minimum groups is still *north* of the maximum group for 1936-38. Such minor positional differences may not alter the relationship of the shifts to sunspot inflection points, but they result in profound differences in the weather, climate, and insect populations of districts that can be influenced in one instance, but not in the other. In fact, prior to the development of the technique illustrated here, which revealed some regularity in the shift, only its direction and amount could be detected by the less satisfactory method employed (36), and it was possible to use 1946-48 as an instance of a *northward* shift of the whole complex of tracks. This was particularly easy to do, since only a restricted area was being investigated in detail, and the proportions of southern and northern centers invading the districts during the two periods, 1936-38 and 1946-48, bore out the direct comparison between the circulation patterns. Fortunately, the insect populations are influenced primarily by the directions and amounts of the shifts, so the insect-climate relationships observed (36) remain valid.

Secondly, in most of the series shown in Figs. 4-6, there are observable differences in the numbers of centers comprising the single groups during the different periods. In fact, there are marked annual fluctuations in the recorded numbers of cyclones and anticyclones that are produced over the whole continent and adjacent oceans. These fluctuations were first noted by Van Cleef many years ago (9) and they and their possible ecological significance have been discussed briefly in an earlier paper (36). They are shown in Fig. 7.

Fig. 7 was constructed by plotting the total annual numbers of each type of center. The whole available map area was used to construct this figure, since it was designed to show fluctuations in total production of all groups, not just of those from restricted areas. Use of the whole map introduces an error that would be serious in an intensive study, because the available map area has been increased occasionally during the period illustrated, and, in addition, there has been a steady increase in coverage of far northern areas since the early part of the 1940 decade, so that more of the pressure systems that occur there are observed now than during previous decades. The effects of these expansions show quite clearly in Fig. 7, where much of the increase in numbers between
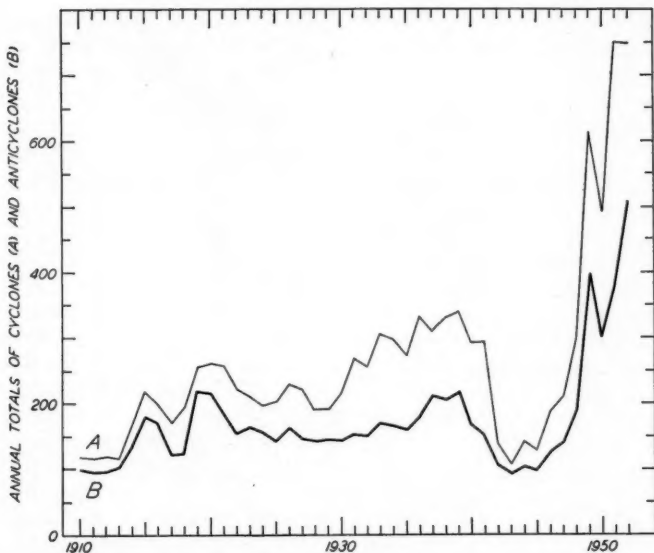
Fig. 7. Fluctuations in the annual totals of cyclonic (A) and anticyclonic centers (B) recorded from the North American charts of the *Monthly Weather Review* between 1910 and 1952.

peaks can be attributed to them. Consequently, from the quantitative standpoint, the minima are more trustworthy than the maxima.

Even with the errors involved, it is clear that there have been orderly fluctuations in total production of the two types of centers, and that the correspondence between the fluctuations in the two types has been remarkably good over the period illustrated. There is, however, little correspondnce between these fluctuations and the positional shifts previously illustrated. Consequently, although order on a continental scale can be demonstrated in both types of fluctuations, the net result in terms of climatic change in any one district must always be determined by detailed examinations. Clearly, the fluctuation in total production sometimes, during its maximum, will reinforce locally increased storminess resulting from a shift of the complex of tracks, and sometimes, during its minimum, will more than counterbalance this effect. Therefore, at this point, examples are included to show how the techniques may be adapted for study of the climate of particular districts, with special reference to the insect population changes occurring there. The first example, Fig. 8, shows the type of approach used in an earlier publication (38), and provides a link with the previous illustrations of the present series. It is a sounder technique for ecological studies than the preceding method that demonstrated track shifts, but it is still much inferior to any method that would make direct use of air masses and fronts.

Applications to Population Studies

The diagrams in Fig. 8 were also constructed from the monthly records of tracks of cyclonic centers, but they were made by an adaptation of a method developed several decades ago. In this method (15, 16), a grid based on each five degrees of longitude and each two and one-half degrees of latitude is laid
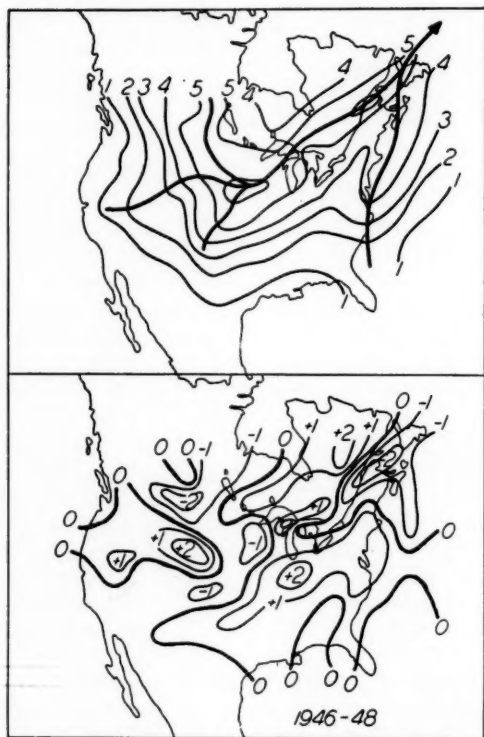
Fig. 8. The average numbers of cyclonic centers of all types for May, June and July, based on the period 1926-49, are shown in the upper diagram. The lower diagram shows the deviations from these long-term averages during the period 1946-48.

out, and totals of cyclonic centers of all types that pass through each rectangle are counted and entered in the rectangles. Iso-lines are drawn to join points having equal numbers of centers. In general, only annual totals are considered.

The upper diagram of the pair in Fig. 8 was constructed much as described above, but only three-month totals were used. To facilitate comparisons between Figs. 4-6 and Fig. 8, the months of May, June, and July have been used again, and the diagram shows the distribution of the average numbers of cyclonic centers based on the period 1926-1949. The arrow shafts drawn through the zones of maximum numbers show the rough correspondence of these to the group paths in the earlier figures.

In a previous publication (38), the grid numbers for four-year periods preceding outbreaks of the spruce budworm were averaged, and their deviations from the long-term averages were plotted and connected by isanomals. In that instance, annual numbers were used. Here, the same method has been used to obtain the deviations of May, June, and July for the period 1946-48 from their long-term averages. Once again, the period of years was chosen so that results could be compared with the diagrams in Figs. 4-6. The completed diagram is shown in the lower part of Fig. 8.

In this diagram, the heavy zero lines pass through areas where there were no deviations from the long-term averages during 1946-48, and separate regions where there were either positive or negative deviations. These deviations result partly from differences in available numbers of centers, and partly from differences in path direction, which are rather difficult to untangle from Figs. 4-6, but which can be seen by close study.

Although this diagram was constructed for 1946-48 primarily because this was the latest period among those of the previous series of figures, it is interesting to note in it evidences of associations with insect population trends previously described (36, 38). For example, the + 1 isanomals outlining the areas north and west of Lake Superior, and from northern Michigan across to the north shore of Lake Huron, enclose areas within which outbreaks of the forest tent caterpillar appeared about 1948. This agreement is to be expected from observed associations between increased numbers of cyclonic centers passing through an area and increases in populations of tent caterpillars within it (36). Similarly, the negative area overlying the north shore of the St. Lawrence and northern New Brunswick appears to be closely associated with the appearance of increases in spruce budworm populations noted, in New Brunswick, at least, about 1947. This also is in accord with previous observations (38). If maps were to be prepared specifically to illustrate these two associations, they would have to be drawn for 1944-47 for the forest tent caterpillar, or for 1943-46 for the spruce budworm, but the relationships are marked enough so that there is still a good indication of them in the present illustrations.

The method is quite useful for determining the distributions of areas of excessive or deficient cyclonic activity for comparison with observed distributions of insect outbreaks. It would be much improved if it were restricted to centers issuing from one or two types of source regions, so that the interplay between northern and southern centers in one region could be observed. For example, if only centers originating south of 40°N. were plotted on one map, and only centers originating north of 55°N. (to allow for smaller map sizes in earlier maps) were plotted on another, it should be possible to see the shifts from year to year as readily in this type of presentation as in the type shown in Figs 4-6, and, in addition, quantitative deviations could be obtained for use in specific areas. To date, the excessive labour involved in handling the whole map in this way has barred the development of this part of the work. Instead, a modification of the approach has been applied in a few small areas in which outbreaks of spruce budworm or forest tent caterpillar have occurred. One way in which the results may be illustrated is shown in Fig. 9.

Three-year running means of the annual numbers of all types of cyclonic centers passing through a particular rectangle of the grid have often been plotted to show year-to-year fluctuations (e.g., 13). In Fig. 9, similar information for one region is presented but, in addition, the numbers of cyclones for May, June, and July are shown, and these three-month totals have been further divided to show the numbers from different source regions. Triangles mark the years in which outbreaks of forest tent caterpillar were reported to have begun in the region (the portions of Alberta, Saskatchewan, and Manitoba between 100-115°W and 52.5-55°N.).

Fig. 9 shows the fluctuations in numbers of passing centers that originated in the Southwest (A), in the cP source region (B), and over the Pacific (C). Curve D shows the totals of all three types for the three-month period each year. Curve E is an example of the older method of illustration, in which the annual
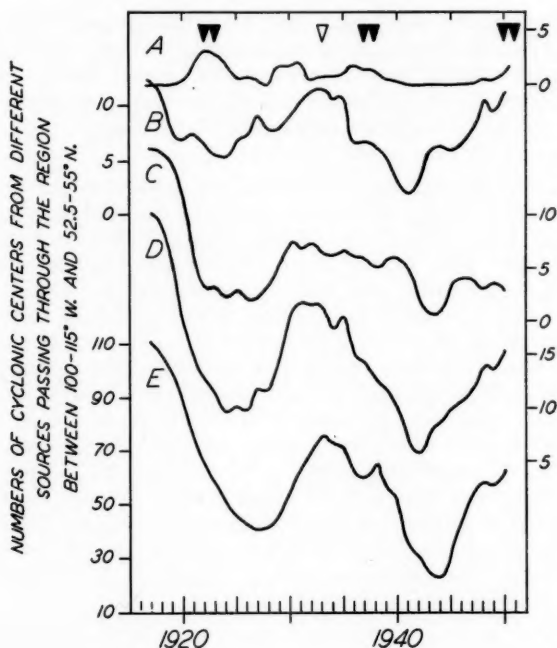
Fig. 9. Three-year running means of the numbers of cyclonic centers passing through the portions of Alberta, Saskatchewan, and Manitoba between 52.5-55°N. and 100-115°W. during May, June and July. Curve A shows the fluctuations in the numbers of centers that originated in the southwestern part of the continent, curve B shows the centers from the vicinity of the polar continental source region, and curve C shows centers from the Pacific. Curve D shows the totals of all three types for the three-month period each year, and curve E shows the annual numbers of all three types. The triangles at the top show the years in which outbreaks of the forest tent caterpillar were reported to have begun in the region. The open triangle indicates an outbreak that apparently died out the following year.

numbers of all types of centers were plotted. The slight smoothing that has been applied for publication at a reduced scale does not alter the obvious trends shown.

It is clear that the outbreak dates reported for forest tent caterpillar throughout the region are closely associated with the appearance of centers from the south, a further example of an association already noted (36, 37). The outbreak date, 1933, shown by the open triangle is especially interesting, because this infestation apparently died out in 1934, whereas others in the 1920's and 1930's continued for several years. It is possible that the sudden, excessive northern activity shown in Curve B contributed to this collapse, because the continued southern activity was associated with the appearance of a group of major outbreaks when the northern activity again diminished. The outbreaks reported during the 1950's also began during a high level of northern activity in addition to the southern invasions, so that their eventual duration, whether brief or extended, should provide additional information on this point. (In this connection, it is interesting to note that, although marked increases over the preceding year were reported during 1952, Forest Biology Survey reports for 1953 indicated

declines in many of the populations. Some of the mortality was attributed to unseasonably cold weather in the early part of the larval period. At the date of writing, the situation for 1954 is unknown).

DISCUSSION

Most of the material included in the preceding pages does not require a direct, point by point discussion. It was arranged to provide some necessary background information and some reference material to which the interested reader could turn. In addition, it was designed to point out a line of thought that could be followed in subsequent ecological work. With this latter point in mind, most of the comments in the following discussion have been included as part of a general framework within which that line of thought and all the material in the preceding pages should be considered.

Interest in the preventive aspects of applied entomology is steadily mounting, but any preventive program must contain and, indeed, must be preceded by, suitable methods of forecasting population changes. Such predictions can only be based on a knowledge of the complex of factors that govern the fluctuations of an insect population, and their accuracy depends entirely upon how well the interactions of these factors is understood. The natural preoccupation of biologists with the density-dependent biotic factors of the governing complex has led to the present impasse; namely, that no system of forecasting biological events that is based solely on interacting biotic factors is particularly successful. A change of opinions about the role of meteorological factors would help.

For example, weather and climate are often considered simply as the broad framework within which the complicated biotic interactions take place. This viewpoint hastens the process by which numerous instances of the direct effects of meteorological factors on insects are relegated to the limbo of density independence so that the biological heart of the problem may be pursued without further distraction. Predictive systems lose a number of potentially valuable facts in this way. More important, however, this viewpoint leads to total disregard of the indirect effects of meteorological factors on the equilibrium of a population by their action on its habitat, its parasites, its diseases, and the supply and quality of its food. Some indirect effects may act in rather unexpected ways. For example, resin production inhibits the emergence of the larvae of *Diprion* (*Gilpinia*) *frutetorum* (F.), and Thalenhorst has suggested (34) that population increases observed during periods of drought and unusually high temperatures may occur because of decreased resin production. Wider recognition of the existence of indirect effects of weather and climate could lead to a better understanding of the population dynamics of a species.

Several difficulties are commonly encountered in attempts to assess the effects of meteorological factors on population changes. One stems from our sometimes unavoidable preoccupation with the years of near-peak populations. Although restriction of investigations to this brief period seriously hampers study of any part of the controlling complex, it generally succeeds in completely obscuring any basic effects of climate. To assess climatic influence correctly, it is necessary to examine climatic variations during the period immediately preceding or coinciding with the beginning of an outbreak of an insect that exhibits violent fluctuations in numbers, instead of studying the climate while the outbreak exists. This follows from the concept of climatic release of a small, indigenous population. That is, in a region where a species exists in small numbers, and in which biotic conditions already favour population growth, no initial increase may occur until

seasonal climatic control is relaxed. The important point to keep in mind, however, is that favourable weather may have to recur several years in succession before a major increase in population can develop. Once the enormous potential for increase that such a species possesses is realized, the population grows so rapidly that no combination of adverse physical and biotic factors can halt it immediately. Since it is usually during this period that the outbreak is studied, it is not surprising that effects of the various original governing factors are often obscured.

Another difficulty in assessing the effects of meteorological factors has arisen because of the widespread belief that climate is relatively static, so that observed fluctuations in it must be simply random fluctuations about a mean. Consequently, it has seemed reasonable to conclude that any climatic changes observed to have an effect on a changing population were, perforce, only accidentally linked with a particular phase of population growth or decline. As belief in the *complete* randomness of climatic changes becomes less fashionable, this difficulty should disappear along with it.

Acceptance of the idea of a dynamic climate, however, will not automatically create a fully-rounded predictive entomology, because this depends ultimately on the development of satisfactory long-term forecasts of climatic change: a type of forecast that does not yet exist. Therefore, really satisfactory forecasts of biological events must at present be confined to short-term phenomena, such as those discussed in the first section of this paper. In this field, present weather forecasts are accurate enough. In the long-range field, population ecologists for a time must be content to add the concept of a dynamic climate to their working hypotheses. This concept, combined with modern ideas about atmospheric circulation processes, should permit collection of information on factors governing population changes in such a way that work on any insect could be brought to the point where it could be quickly fitted into the framework of any future system of long-range weather forecasting.

Another point for discussion is the implied relationship between solar phenomena and the shifts in storm tracks noted in Figs. 4-6. It has never been very sound policy to ignore the possible effects of solar phenomena on meteorological events, although it has often been a popular pastime. On the other hand, when solar phenomena appear to intrude, it is not yet possible to do very much with them. Consequently, ecologists in general will be on safer ground if they simply await further developments in this field. Certainly, from the meteorological standpoint, it will eventually be necessary to consider effects of fluctuations in solar phenomena before we can approach a complete understanding of how changes in the general circulation occur. Meanwhile, this does not mean that ecologists must think in terms of fractions of sunspot cycles before they can benefit from the concept of a dynamic climate. A better and more thought-provoking approach would be to ask, "What would happen if seven of the next ten summers were dry, and then five of the next nine were wet?"

Occasionally, there are attempts at direct correlations between population fluctuations and sunspot data that establish apparent relationships within particular regions. Many similar attempts to relate single meteorological variables to sunspot fluctuations have failed as soon as they have been extended beyond the area in which the correlation was first observed, and attempts with biological material are apt to fail for the same reason; namely, exclusion of the general circulation and its effects from the problem. For example, variations in temperatures are first of all the result of changes in the general circulation. Although this in turn

may perhaps be affected by changing solar phenomena, it cannot change in the same direction in all its parts at the same time.   Therefore, simple correlations of temperature variations with sunspot variations seldom can be extended far from a specific locality, and that locality must be in a special part of the circulation. Similarly, if sunspots directly affect the population changes of an insect as widely distributed as the forest tent caterpillar, one would expect populations through-out the range of the insect to rise or fall more or less together. This seldom occurs. More frequently, there is a brief lag between population increases in different regions, and this lag, *or its absence*, can be related to special changes in the general circulation much more plausibly than to an overall change in solar activity. It is for such reasons that occasional suggestions of a direct effect of ultraviolet on insect populations should still be viewed with caution (cf. 17, 30, 31). At present, they simply remove the problem of population changes from the area where it can be attacked by climatological methods to an area where it cannot yet be properly attacked.

Several authors (8, 19, 29) have pointed out that European populations of widely separated taxonomic groups have tended to rise and fall together during particular periods. Many interesting investigations may be developed if the problem is considered in the following manner.

First, it is necessary to postulate more orderly variation in the climate of an area than was hitherto supposed. Secondly, it is necessary to classify the taxo-nomically unrelated species in terms of the ways in which they occupy their habitats.   For example, some leaf miners or rollers have been observed to increase together, to be followed later by tent-formers, and finally by open feeders known to be adversely affected by drought. If one tentatively accepts the idea of a more or less orderly variation in climate from, say, clear, dry summers through a cloudier, moister period to a number of wet summers, interesting hypotheses may be developed for testing. For example, perhaps the small shelters of the miners and rollers are only efficient greenhouses when there is ample solar heat, whereas the larger tents of the later species are most beneficial when there is more frequent cloud.

Over a period of years, such hypotheses could be tested in the field.   Prefer-ably, the studies should be confined to insects on one kind of tree or plant, so that accurate determinations of the sequence of changes in the various populations could be referred to a restricted overall habitat.   During 1953, the Bioclimatology Section of the Forest Biology Division began an investigation of this type on poplar insects and diseases in the vicinity of the Continental Divide. The location was chosen because the climate frequently differs on the two sides of the Divide. If organisms common to both sides are selected, it is often possible to observe the effects of two different climates on two populations within a few miles of one another.

SUMMARY

The more important types of air masses affecting the weather and climate of North America are described briefly, together with their source regions. A general description of frontal systems is given, with particular attention to the effects of the passages of cold fronts or their associated instability lines on insect activity and dispersal. Similarly, an example is included to show how some principles of air-mass climatology may be used in investigations of the vertical and annual variations in insect mortality.

The remainder of the paper contains descriptions of indirect methods of assessing climatic variations in a way that may show the part played by atmo-

spheric circulation processes. Examples presented are based on records of passages of anticyclonic and cyclonic centers given in the *Monthly Weather Review*.

Many of the examples show the shifts observed in the tracks of groups of pressure centers originating in or near air-mass source regions. In addition, attention is drawn to the annual fluctuations in numbers of centers produced. The effects of both the annual variation in numbers and of the shifts in group positions on the numbers of centers passing through a restricted area are also shown. The latter example also shows the association between forest tent caterpillar outbreaks and increasingly frequent invasions of an area by southern or southwestern cyclonic centers.

Emphasis is placed on the need for considering indirect, as well as direct effects of climate on population densities, and on the need for examining climate during the period before an outbreak, instead of during the outbreak proper. In addition, it is suggested that it is unwise to attempt direct correlations between population changes and variations in sunspots or ultraviolet, when due regard for the effects of atmospheric circulation processes often can produce more trustworthy results.

ACKNOWLEDGMENTS

This paper is the outcome of numerous discussions with many entomologists of the Forest Biology and Entomology Divisions during the past few years, and thanks are due to all whose questions and critical discussions have led to its development in its present form. I also wish to thank Dr. H. C. Willett, Department of Meteorology, M.I.T., Mr. E. B. Watson, Forest Biology Division, Ottawa, and Mr. M. G. Thomson and Dr. J. A. Chapman, of this laboratory, for reading the manuscript. Miss P. M. G. West assisted with the compilation and preparation of the data.

REFERENCES

1. Ahlmann, H. W. The present climatic fluctuation. *Geogr. J.* 112: 165-195. 1949.
2. Ahlmann, H. W. Glacier variations and climatic fluctuations Amer. Geogr. Soc. Bowman Memorial Lecture, Ser. 3. 1953.
3. Alaka, M. A., C. L. Jordan and R. J. Renard. The jet stream. U.S. Bureau of Aeronautics (Navy) NAVAER50-IR-249. 1953.
4. Berry, F. A., Jr. and E. Bollay. Air masses. *In* Handbook of meteorology: 604-637. 1945.
5. Berry, F. A, Jr, E Bollay, and N. R. Beers (eds) Handbook of meteorology. McGraw-Hill, New York. 1945.
6. Brooks, C. E. P. Climate through the ages. Benn, London. 1949.
7. Brooks, C. E. P. Geological and historical aspects of climatic change. *In* Compendium of meteorology: 1004-1018. 1951.
8. Carpenter, J. R. Insect outbreaks in Europe. *J. Anim. Ecol.* 9: 108-147. 1940.
9. Van Cleef, E. Is there a type of storm path? *U.S. Weather Bur. Monthly Weather Rev.* 36: 56-58. 1908.
10. Henson, W. R. Mass flights of the spruce budworm. *Can. Entomol.* 83: 240. 1951.
11. Henson, W. R., R. W. Stark, and W. G. Wellington. Effects of the weather of the coldest month on winter mortality of the lodepole needle miner, *Recurvaria* sp., in Banff National Park. *Can. Entomol.* 86: 13-19. 1954.
12. Hewson, E. W. and R. W. Longley. Meteorology, theoretical and applied. Wiley, New York. 1944.
13. Huntington, E. Mainsprings of civilization. Wiley, New York. 1945.
14. Klein, W. H. The weather and circulation of December 1951. *U.S. Weather Bur. Monthly Weather Rev.* 79: 218-221. 1951.
15. Kullmer, C. J. The latitude shift of the storm track in the 11-year solar period. Smithsonian Inst. Pubs. Misc. Collections, 89, No. 2. 1933.

16. Kullmer, C. J. A remarkable reversal in the distribution of storm frequency in the United States in Double Hale Solar Cycles, of interest in long-range forecasting. Smithsonian Inst. Pubs. Misc. Collections, 103, No. 10. 1943.

17. Laidlaw, W. B. R. A preliminary enquiry into the influence of solar radiation on insect environment, with special reference to the relation between pest epidemics and fluctuation in solar radiation. *Trans. Soc. Brit. Ent.* 11: 17-80. 1951.

18. Lewis, J. B. The effect of weather upon insect populations. *M. Sc. Thesis*, McGill University. 1950.

19. MacLagan, D. S. Sunspots and insect outbreaks: an epidemiological study. *Proc. Univ. Durham Phil. Soc.* 10: 173-199. 1940.

20. Malone, T. F. (ed.) Compendium of meteorology. Amer. Met. Soc., Boston. 1951.

21. Manley, G. Climatic variation. *Quart. J. Roy. Met. Soc.* 79: 185-209. 1953.

22. Namias, J. The index cycle and its role in the general circulation *J. Met.* 7: 130-139. 1950.

23. Namias, J. The jet stream. *Scientific American* 187: 26-31. 1952.

24. Namias, J. and P. F. Clapp. Observational studies of general circulation patterns. *In* Compendium of meteorology: 551-567. 1951.

25. Petterssen, S. Introduction to meteorology. McGraw-Hill, New York. 1941.

26. Petterssen, S. Changes in the general circulation associated with the recent climatic variation. *Geogr. Ann.* 31 (Ahlmann Vol.): 212-221. 1949.

27. Rainey, R. C. Weather and the movements of locust swarms: a new hypothesis. *Nature* 168: 1057-1060. 1951.

28. Rossby, C-G. and H. C. Willett. The circulation of the upper troposphere and lower stratosphere. *Science* 108: 643-652. 1948.

29. Schwerdtfeger, F. Ueber Herdtheorie und Massenwechsel der Insekten. *Anz. Schädlingsk.* 18: 121-124. 1942.

30. Shelford, V. E. Fluctuation of non-forest animal populations in the Upper Mississippi Basin. *Ecol. Monogr.* 21: 149-181. 1951.

31. Shelford, V. E. Fluctuation of forest animal populations in east central Illinois. *Ecol. Monogr.* 21: 183-214. 1951.

32. Sheppard, P. A. The jet stream and related phenomena. *Science Progress* 39: 483-495. 1951.

33. Tannehill, I. R. Drought, its causes and effects. Princeton Univ. Press. Princeton. 1947.

34. Thalenhorst, W. Vorzeitiger Zusammenbruch einer Massenvermehrung von *Gilpinia frutetorum* F. (Hym. Diprionidae). *Anz. Schädlingsk.* 26: 53-56. 1953.

35. Wellington, W. G. The effects of variations in atmospheric pressure upon insects. *Canad. J. Res.*, D, 24: 51-70. 1946.

36. Wellington, W. G. Air-mass climatology of Ontario north of Lake Huron and Lake Superior before outbreaks of the spruce budworm, *Choristoneura fumiferana* (Clem.), and the forest tent caterpillar, *Malacosoma disstria* Hbn. (Lepid.: Tortricidae; Lasiocampidae). *Canad. J. Zool.* 30: 114-127. 1952.

37. Wellington, W. G. Weather and climate in forest entomology. *Met. Monogr.* (*In Press*).

38. Wellington, W. G., J. J. Fettes, K. B. Turner, and R. M. Belyea. Physical and biological indicators of the development of outbreaks of the spruce budworm, *Choristoneura fumiferana* (Clem.) (Lepid.: Tortricidae). *Canad. J. Res.*, D, 28: 308-331. 1950.

39. Willett, H. C. Long-period fluctuations of the general circulation of the atmosphere. *J. Met.* 6: 34-50. 1949.

40. Willett, H. C. Solar variability as a factor in the fluctuations of climate during geological time. *Geogr. Ann.* 31 (Ahlmann Vol.): 295-315. 1949.

41. Willett, H. C. Extrapolation of sunspot-climate relationships. *J. Met.* 8: 1-6. 1951.

The Crow Flea, *Ceratophyllus rossittensis* Dampf, in North America (Siphonaptera: Ceratophyllidae)[1]

By George P. Holland[2]

Systematic Entomology Unit, Entomology Division
Ottawa, Canada

Ceratophyllus swansoni Liu, 1935, was described from one male and one female specimen collected from a long-eared owl, "*Asio wilsonianus*" [*A. otus* ssp.], at Fertile, Minnesota. The species is not well known in collections, and the writer knows of only one other published record, from Beaverhead Co., Montana, reared from nests of the same owl (Jellison *et al.*, 1943). The host affinities of *C. swansoni* have remained uncertain, as predatory birds are not usually normal hosts of fleas.

Recently, however, several collections of this species have been made from the nests of crows, *Corvus brachyrhynchos* Brehm, in the Ottawa district. Sufficient numbers have been collected to suggest a true association between this flea and the crow. As it is well known (e.g., Bent, 1938) that long-eared owls frequently, if not usually, make use of old crows' nests, the presence of *C. swansoni* on these birds becomes easily explained. Further, one of the collections from a crow's nest was made in the late fall, suggesting that the fleas overwinter in such nests in the adult stage; thus they would be waiting in the spring for fresh occupants of the nest, which might be crows or owls.

It appears then that North American crows possess their own specific flea. That it is widely distributed is also shown, but it may be locally rare. Otherwise it is remarkable that such a relationship has remained so long undetected in view of the abundance of the hosts and the frequency with which they are "collected".

The discovery of a true crow flea in North America suggested a comparison with the European crow flea, *Ceratophyllus rossittensis* Dampf, which occurs, though evidently not commonly, on the carrion crow, *Corvus corone* L., and the hooded crow, *Corvus cornix* L. Three pairs of *C. rossittensis* have been available for study and comparison with *swansoni* and leave little doubt that they are conspecific. On the basis of this material, it appears that the movable process of the clasper (♂) is proportionately longer in the European form (Figs. 1 and 3), but there is considerable variation in the shape of this structure in one series from Carp, Ontario, although in no specimen does it match in length the specimens of true *rossittensis*. It seems justifiable at this time, then, to retain the name *swansoni* in a subspecific sense, although future comparison of more representative material may indicate that it should be dropped. No reliable differences were found in the females (e.g., Figs. 2 and 4).

A European subspecies, *C. rossittensis monasteriensis* Peus, has been described, but its status appears to be in some doubt; it cannot be appraised in this paper.

C. rossittensis swansoni belongs to the *gallinae*-group of the genus, which includes, in the Nearctic region, *C. gallinae* (Schrank), *C. niger* Fox, and *C. lari* Holland. It may be distinguished from these in the male by the fixed process (P), which is noticeably pointed (Fig. 3) rather than broadly rounded; and by the position of the dorsal membranous appendage (Mb) of sternum VIII, which is situated well back from the apex of that sclerite in this species but is apical in
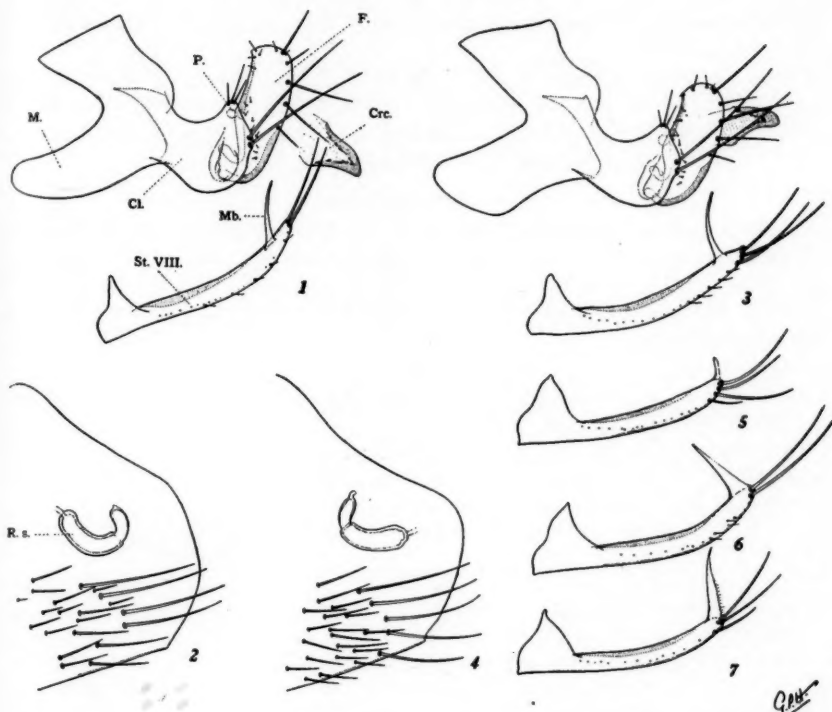
Fig. 1. *Ceratophyllus r. rossittensis* Dampf. Clasper and sternum VIII of male (Reipzig am Oder, Germany). Fig. 2. *C. r. rossittensis*. Spermatheca and sternum VII of female (Reipzig). Fig. 3. *C. rossittensis swansoni* Liu. Male (Carp, Ontario). Fig. 4. *C. r. swansoni*. Female (Carp). Fig. 5. *C. lari* Holland. Sternum VIII of male. Fig. 6. *C. gallinae* (Schrank). Fig. 7. *C. niger* Fox.

the others (Figs. 5, 6, and 7). Females may be distinguished from those of *gallinae* and *niger* by the posterior abdominal spiracles, which have the fossa appearing doubled up, as in *lari*. They are difficult to separate from females of *lari;* that species, however, is known only from Great Slave Lake, N.W.T., on gulls.

In considering the Palaearctic and Nearctic distributions and host-relationships of *C. rossittensis*, it is worth noting that some ornithologists (e.g., Meise, 1928) regard *Corvus brachyrhynchos* as conspecific with *C. corone;* however, this view is contested by others. Also, it is interesting to record an occurrence of *C. rossittensis* on *Asio otus* in Europe. This Holarctic species of owl makes regular use of old nests, especially those of crows, in the Old World as well as in the New.

Specimens Examined

Germany: Reipzig am Oder (near Frankfurt), Brandenburgh, 10.V.28, ex *Corvus cornix* L., 1 ♂, 2 ♀ (G. Stein); Reipzig am Oder, 25.V.28, ex *Asio otus* (L.), 1 ♂ (G. Stein); Münster, Westfalen, 30.IV.46, ex nido *Corvus corone* L., 1 ♂, 1 ♀ (F. Peus).

United States: Beaverhead Co., Montana, reared 1937, ex nido "*Asio wilsonianus*", 1 ♂, 1 ♀.

Canada: Osgoode, Ontario, 9.VI.53, ex nido *Corvus brachyrhynchos* Brehm, 1 ♂, 2 ♀ (R. de Ruette); Osgoode, 13. VII. 53, ex nido *C. brachyrhynchos*, 1 ♂, 1 ♀ (R. de Ruette); Carp, Ontario, 24.XI.53, ex nido *C. brachyrhynchos*, 21 ♂, 10 ♀, plus many more in alcohol (J. E. H. Martin).

Acknowledgments

References

Bent, A. C. 1938. Life histories of North American birds of prey (part 2), orders Falconiformes and Strigiformes. *Smiths. Inst., U.S. Natl. Mus. Bull.* 170; viii+482 pp.; 92 pl.

Dampf, A. 1913 *Ceratophyllus rossittensi*s n. sp., ein neuer Vogelfloh aus Ostpreussen. *Schrif. Physik. Oekon. Gesel. Königsberg* 53: 345-351; 6 figs.

Jellison, W. L., G. M. Kohls, and H. B. Mills. 1943. Siphonaptera: species and host list of Montana fleas. *Montana State Bd. Ent. Misc. Pub.* 2: 22 pp.

Liu, C. Y. 1935. Two new bird Ceratophylli from Minnesota. *Ann. Ent. Soc. Amer.* 28: 121-124; Pl. 1.

Meise, W. 1928. Die Verbreitung der Aaskrähe (Formenkreis *Corvus corone* L.). *J. Ornithologie* 76: 1-203.

Peus, F. 1941. Uber Krähenflöhe und Krähen. *Zeitschr. Morphol. Okol. Tiere* 37: 426-454; 4 figs.

(Received May 23, 1954)

954

us",

nm,
pos,
pos,

um
ma-
onal
ows

oni-
sen.

t of

28:

J.

454